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HUMAN EATING BEHAVIOR: PREFERENCES, CONSUMPTION PATTERNS, AND BIORHYTHMS

by

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This project was initiated by Dr. Harry L. Jacobs, Chief, Behavioral Sciences Division, Food Sciences Laboratory, U.S. Army Natick Research & Development Command, Natick, Massachusetts, through discussions with Dr. Howard Levine, New Britain General Hospital and Dr. Franz Halberg, Univ. of Minnesota, over a period of several months prior to the start of this contract.

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Food habits and several daily self-measures of psychophysiological performance were obtained from twenty-three adult volunteers offered canned and frozen military rations for a 12-week period. After 6 weeks of *ad libitum* choice, their daily caloric intake was restricted to a single morning or evening meal. Results were analyzed in terms of correlates of verbal preference, smorgasboard sampling and actual choice and intake, and in the effect of the single daily meals on shifting the circadian rhythms of physiological and psychological variables, and in maintaining body weight as compared with the *ad libitum* situation.

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PREFACE

This study depended completely on the extraordinary cooperation of the experimental subjects, who devoted hundreds of hours to self-administered questionnaires, self-measurements, and the recording of data on food consumption. For months they carefully followed stringent restrictions on their food choice and consumption. It is with admiration and the deepest appreciation that the authors acknowledge this contribution.

Fundamental to this research was NARADCOM Contract DAAK03–74–C–0233 with New Britain General Hospital, under the supervision of Dr. Howard Levine, Chief of Medicine. Under subcontract much of the fieldwork and most of the analyses were conducted by the Chronobiology Laboratories, University of Minnesota Medical School, under the direction of Dr. Franz Halberg. Mrs. Erna Halberg, Dr. Walter Nelson, and Robert Sothern of the Chronobiology Laboratories were responsible for a great deal of the coordination and daily planning, both in gathering data and in analyzing results. Also at the University of Minnesota, Terry Teslow, Mark Thompson, and Jung-Keun Lee provided computer summaries of the data and computations of statistical analyses; Dr. Darwin Hendel participated in designing and gathering data on a certain menu-preference aspect of the research which was beyond the scope of the original research plan.

At various stages of the work, advice and assistance provided by staff of the Behavioral Sciences Division, Food Sciences Laboratory, U.S. Army Natick Research and Development Command, under the direction of Dr. Harry L. Jacobs. Of particular note are the contributions of Dr. Thomas Nichols, CPT James R. Siebold, Ph.D., Dr. Emil Becker, Ms. Nancy Cobean, Ms. Constance Stepp, Ms. Marjorie Berman, SP5 Ronald Cotta, and Dr. Edward Hirsch, now at Mt. Holyoke College.

Among the authors of this report, CPT R. Curtis Graeber, Ph.D., Behavioral Sciences Division, Food Sciences Laboratory, U.S. Army NARADCOM, Natick, MA; now at the Department of Military Medical Psychophysiology, Walter Reed Army Institute of Research, Washington, DC, served as Project Officer and was largely responsible for planning and coordinating all the work and preparing this report. Dr. Ronald Gatty, Baruch Graduate Business Center, CUNY, New York, NY, contributed mainly to the experiment's design, planning the statistical analyses, and overseeing the statistical interpretation of the data. Dr. Howard Levine, Department of Medicine, New Britain General Hospital, New Britain, CT, served as the major research contractor and supervised the New Britain portion of the study. The fundamental chronobiological concepts are largely due to Dr. Franz Halberg, Chronobiology Laboratories, Health Services Center, University of Minnesota, Minneapolis, MN, who also gave a great deal of time and earnest cooperation to make this study possible.

SUMMARY

The food preferences and eating behavior of twenty-three adult volunteers were studied over a twelve-week span during which they ate only canned or frozen military rations. At the same time they self-measured a variety of physiological, psychological, and performance variables several times daily. The first six weeks focused on the relationship between individual food preferences and choice behavior and on individual eating patterns. Subjects could freely eat as much of whatever rations they wanted whenever they chose. The second six weeks examined the effect of mealtiming on biorhythms, performance, and food preferences. In a counterbalanced design the volunteers ate only in the morning for three consecutive weeks and only in the evening for three more.

Subjects' hedonic and desired-frequency preference ratings were highly correlated and produced the same relative scale of food likes and dislikes. The ratings for canned items decreased following two weeks of eating experience, while those for the frozen items did not. Conversely, preferences for unavailable, non-ration foods increased. Preference ratings obtained after a smorgasboard sampling of each ration item were poor predictors of individual choice behavior, but predictability increased with increased ration and preference test familiarity and during restricted mealtiming.

Individual *ad libitum* eating patterns were analyzed into the number and size of meals eaten during successive two-hour blocks of the day. These patterns were relatively stable within subjects, who ranged from those who regularly ate three meals per day with little variation in time or amount to a few who ate at least once during each of the day's twelve two-hour intervals in amounts varying over 400% in calories.

Consumption of all basic nutrients decreased equally during the first three weeks of mealtime restrictions. Subjects switched to eating dinner only during the last three weeks increased their intake to compensate for the loss while those switched to breakfast only did not. Subjects lost more weight during the breakfast-only restriction than during dinner-only, but this loss was due more to the timing of the meals than to the decrease in calories consumed. Changes in mealtiming also shifted the peak times of the circadian rhythms for pulse, diastolic blook pressure, oral temperature, and several blood constituents, but did not shift the rhythms for simple task performance (eye-hand coordination, grip strength, adding speed, and finger counting) or mood and vigor ratings.

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HUMAN EATING BEHAVIOR: PREFERENCES, CONSUMPTION PATTERNS AND BIORHYTHMS

INTRODUCTION

Purpose of Study

The Army's primary interest in food stems from its effect on the ability of individual soldiers to perform. Commanders have long recognized the importance of food in determining both the nutritional and psychological well-being of their troops. Consequently both the Quartermaster and Surgeon General have invested considerable resources to examine ways of optimizing Army nutrition. Much of this effort has gone to improve the rations themselves in terms of nutritional content, packaging, and flavor. Other work has focused upon determining the food preferences of the military in order to best match Army menus with soldiers' food likes and dislikes. Hopefully, the proper use of such information will help guarantee adequate nutrition and improve troop morale and performance.

As will be shown later, most studies concerned with these matters have dealt with large groups of military subjects. In the final analysis, however, the relevant questions revolve around the food-related attitudes and behavior of individual soldiers. To understand human food behavior more fully, it is necessary to study subjects as individuals before generalizing about group behavior. Group-related factors can obscure the operation of critical variables. This need was one of the main reasons for conducting the present study. Further impetus was provided by the realization that the Army has *traditionally ignored* the potential importance that mealtiming may have in determining peak performance levels throughout the day. The intriguing possibility that performance could be further maximized by combining the appropriate timing of meals with well-liked, nutritious food certainly deserves serious scientific and military consideration.

While the work described in this report covers several areas of scientific investigation, each is related to the other in terms of a single underlying factor: an understanding of the individual person's attitudes and behavior in relation to food. The overall purpose was to examine human eating preferences and behavior from several perspectives beginning with the preference and choice of different food items, continuing to the actual pattern of ingestion, and on to the effects of such behavior upon the physiological and psychological state of the individual.

While a comprehensive study of eating is unusual, there are several aspects of this research design which make it unique. Of foremost importance is the relatively long duration of the study combined with the continual availability of a fixed number of foods of known nutritional composition. As a result, subjects were guaranteed a continuous choice situation as to what, when, and how much to eat. This long-term **ad libitum** condition allowed each individual to develop his or her own patterns of food choice and

consumption without sacrificing data on nutrient intake. Also critical was the cooperation and dedication of the volunteer subjects who agreed to limit their diet to military rations for twelve or more weeks, and who recorded the amounts of all food items they ate, in addition to self-measurements of a variety of physiological and psychological variables every three or four hours. These data, combined with those from periodic paper-and-pencil preference surveys provided a rich empirical background against which to view the very important, yet poorly understood, experience of eating in humans.

There are many questions which can be posed within the scope of this research design:

a. How does the format of a preference questionnaire affect the ratings given to individual food items?

b. How does the experience of eating certain foods affect one's stated food preferences for those, as well as other foods?

c. How do mealtime restrictions affect stated food preferences and nutrient intake?

d. How well do people's stated preferences for different foods predict what they will actually choose to eat?

e. What types of eating patterns do individuals set for themselves when exposed to an ad libitum supply of food? This includes meal-patterning, snacking, food choice, and nutrient consumption.

f. Does mealtiming affect body weight changes and the known circadian rhythms of physiological variables?

g. Are circadian rhythms manifested in changes of psychological state and in the performance of psychomotor tasks? Also, how are such rhythms affected by alterations in mealtiming?

More detailed questions are raised within each of the three major sections of this report. Hopefully, the answers provided and the suggestions offered will significantly increase our understanding of the relationship between people and food.

Overall Design of Study

The design of this study is relatively complex both in terms of the number of experimental variables and the assignment of subjects. Therefore, the procedural details relating to the three major areas of investigation will be discussed within the respective subsections of the report. The following presentation is intended to provide the reader with only a general understanding of the overall experimental strategy.

As can be seen in Figure 1, the study was divided into a six-week span of unrestricted, or *ad libitum*, eating followed by a six-week span of restricted eating. The *ad libitum* span was further subdivided into three successive two-week spans, Stages II to IV, which were defined by the types of rations available. These first three stages were designed to provide information relating to two major questions: (1) How well do paper-and-pencil surveys of people's stated food preferences predict actual food choice and consumption? (2) What patterns of eating do individuals set for themselves when there are no restrictions as to how much or when they can eat? During Stages II and III subjects exclusively ate one type of military ration for two weeks followed by the other type of ration for two more weeks. Except for a few beverages and bread, no other foods were allowed; however, all ration foods of the given type were freely available at all times. Time of eating and amount of food eaten were recorded by all subjects throughout the study. This permitted an exact analysis of nutrient intake over time because laboratory nutritional analyses were available for the Meal Combat Individual (MCI) and USAF Pre-cooked Frozen (FROZ) rations which were used. Figure 1 does not reflect the initial Stage 1 of the experiment which had to be prematurely discontinued after a few days due to insufficient supplies of the dehydrated ration being used (see page 35).

Each two-week consumption span was bounded by a set of paper-and-pencil food preference surveys appropriate to the ration. One survey was administered prior to the subject's experiencing the food; an identical survey was given after sampling a smorgasbord of those rations; and a third identical survey was given at the end of the 2-week consumption stage. In addition, the extensive general food preference survey traditionally administered to members of all four military services by the Natick Research and Development Command was completed by these subjects at the beginning and end of the *ad libitum* span. By comparing the results of these surveys with corresponding food choices and consumption, the predictive value of stated food attitudes could be determined. As Figure 1 shows, the order of ration presentation was counterbalanced to minimize any possible influence of sequential variables. By combining the availability of both MCI and frozen rations during Stage IV, similar food preference and consumption data were gathered in relation to an expanded set of foods.

Stages II—IV also provide baseline data on circadian rhythms under *ad libitum* eating conditions to be compared later with similar data collected during mealtime restriction (Stages V and VI). Thus, subjects self-measured a variety of physiological variables (e.g., pulse, blood pressure, oral temperature, etc.) and psychological variables (e.g., mood, task performance, etc.) every 3 to 4 hours throughout each day.

During the second six-week span, Stages V and VI, the subjects were divided into experimental and control groups. Half of the experimental group were required to eat all their daily food soon after awakening in the morning, i.e., as a big breakfast. The other half ate all their daily food in the early evening, i.e., as a big dinner. After three weeks, the two experimental groups switched their eating habits to control for any possible influence of sequential variables. The control subjects ate *ad libitum* throughout the six weeks. Except for the imposed restrictions on mealtiming, all subjects were allowed to

Figure 1. Schematic Representation of General Experimental Design.

AD LIBITUM STAGES

Approximate No. Subjects	Tests	II	Tests	Tests	III	Tests	IV	Tests
9	GC*C	CANNED RATIONS	C	F * F	FROZEN RATIONS	FC	CANNED & FROZEN RATIONS	CFG
9	GF*F	FROZEN RATIONS	F	C * C	CANNED RATIONS	CF		
Time ⟶		2 weeks			2 weeks		2 weeks	

RESTRICTED MEAL-TIME STAGES

Approximate No. Subjects	V	Tests	VI	Tests
8	DINNER ONLY	CF	BREAKFAST ONLY	CFG
9	BREAKFAST ONLY		DINNER ONLY	
6	AD LIBITUM		AD LIBITUM	
Time ⟶	3 weeks		3 weeks	

Preference Surveys: G = General Preference Survey of 378 Foods (Natick Labs 1972 version)
C = Specific Survey of 25 Canned MCI Ration Foods
F = Specific Survey of 24 USAF Precooked Frozen Foods
Smorgasbord of Rations: * = Buffet Sampling of the Surveyed Rations

select freely from both the MCI and frozen rations and to eat as much as they desired at a given meal. As before, records were kept of all food consumption, and self-measurements were performed throughout each day. Thus, this half of the study was designed to examine the effects of mealtime restrictions upon circadian rhythms, both physiological and behavioral, and upon actual food preferences and consumption. Information on attitudinal measures of food preference was available from preference surveys administered at the middle and end of the six weeks. These surveys were identical to the ones administered during the first six weeks of the study. Subjects also completed a circadian rhythm questionnair (Appendix E–5) at the start of the study so that their usual baseline activity patterns could be assessed for "morningness" or "eveningness".

This brief procedural introduction has been limited to describing only the major questions and experimental design features involved in the study. More detailed rationale and procedures are included in the following sections of the report. Although each of these three sections necessarily relate to each other in terms of concomitant data collection, they are written in independent fashion. Therefore, one may read them separately, according to his or her own interests, without jeopardizing the understanding of that section's results.

FOOD PREFERENCES AND PREDICTION OF CHOICE BEHAVIOR

Problem

In attempting to guarantee proper nutrition for its troops, the Army has recently become more aware of the critical role played by soldiers' food likes and dislikes. Despite all efforts to supply nutritious food in dining halls, the final determinant of good nutrition is whether the individual soldier chooses to eat the proper foods. Thus, the problem is eventually a behavioral one. In order to minimize the disparity between available and desired foods, Army psychologists have sought to measure soldiers' food preferences.

Preference measurement may be accomplished either by observing actual food choice behavior or by asking subjects to state their food likes and dislikes on a paper-and-pencil survey form. The latter technique has predominated over the former primarily because of its ease of data collection and potentially larger sample size. The critical question arises, however, as to whether the results of such attitude surveys actually predict food choice behavior. Human nature suggests that people often say one thing and do another. The investigation of this problem constitutes the major aim of this section of the experiment.

Several other secondary questions are also examined. Each of these, however, bears directly on the major issue of the validity of paper-and-pencil food preference surveys. For instance, there is the question of how the experience of eating certain foods affects one's stated preference for those, as well as other foods. Also, whether the context surrounding the name of a food item in a survey can affect the preference rating given to it. Of course, given the rare opportunity to examine food consumption behavior under controlled, long-term restricted mealtime conditions, it is also worthwhile to ask what effects such restriction may have upon stated food preferences and their relation to actual food-choice behavior.

The following literature review provides more detailed background information regarding the major issue of survey validity. Previous findings pertaining to the more secondary questions are discussed later in conjunction with the present results.

Review of Literature

History of Army research. For the purposes of military menu planning, the Army has sponsored many studies of enlisted personnel food preferences. For several years (1949 to 1960) these studies were planned at the U.S. Army Quartermaster Food and Container Institute in Chicago and since 1963 have been centered at the U.S. Army Natick Research and Development Command. There the work is planned and conducted by the Behavioral Sciences Division of the Food Sciences Laboratory, serving all four military services: the Navy, Air Force, Marines, and Army.

By 1949 the Army was developing and testing hedonic ratings for measuring the degree of a person's like or dislike of individual foods. The major concern of this review centers on the use of the hedonic technique in the field to determine soldiers' food-item "preferences" by having them rate different food names according to their general degree of like or dislike. Variations on the basic hedonic technique have also been used in the laboratory for testing product "acceptance", the term used for rating samples of actual food products. In either type of testing, Army researchers have been willing to assume that the ratings can be treated as interval scale data.

Early work demonstrated that results of field testing at specific installations are less reproducible than those found in the laboratory (Peryam and Girardot, 1952).[110] Nevertheless, it was felt that sufficient worthwhile information would be gained to justify undertaking a nationwide U.S. Armed Forces food preference survey (Peryam, Polemis, Kamen, Eindhoven, and Pilgrim, 1960).[112] Hopefully such attitudinal data would be more reliable when summated across different installations and would have more general significance than the results from a single installation in the prediction of food acceptance for menu-planning purposes. Since the initial effort, several other similar national surveys have been conducted for different armed services (Kamen, Peryam, Peryam, and Kroll, 1967;[78] Moskowitz, Nichols, Meiselman, and Sidel, 1972;[97] Meiselman, Waterman, and Symington, 1974).[94] The more recent surveys have added a second measure of food preference by asking subjects to rate each food name as to the number of times (days) per month they would like to eat that item. This measure has typically been referred to as a "desired frequency" rating of food preference.

Preference rating reliability. Several studies have reported high item reliability for food preference ratings obtained in such surveys. Correlation coefficients ranged from 0.95 to 0.99 for the reliability of mean preference ratings for individual foods across various military sample populations using over 2000 subjects (Eindhoven and Kamenetsky, 1956;[25] Peryam et al., 1960).[112] A test-retest correlation of 0.98 was found for both hedonic and desired frequency mean preference ratings for 123 individuals. However, test-retest correlations were much lower ($r = 0.60$ for hedonic data and $r = 0.58$ for frequency data) when computed for individual subjects across all food items (Waterman, Meiselman, Branch, and Taylor, 1974).[147] Smutz et al. (1974)[134] reported similarly low median Spearman rho values (0.74 and 0.64, respectively) for ten individual subjects over 143 foods, although these correlations could have been influenced by the controlled 5-day exposure to the same eating environment and same set of menus between the two preference surveys.

Despite their fair degree of stability, preference survey hedonic ratings are sensitive to environmental factors, demographic differences, and repeated food exposure (Peryam and Pilgrim, 1957;[111] Pilgrim, 1957;[113] Schutz and Pilgrim, 1958;[127] Siegel and Pilgrim, 1958).[132] In one study the ratings indicated that food monotony did not develop as a result of the repeated eating of tested food items (Kamen and Peryam, 1961).[77] This negative finding may have been due to the tendency of survey subjects to respond to food names in relation to their best previous experience with that food item regardless of instructional set (Schutz and Kamenetzky, 1958).[126]

Behavioral validity of survey research. The issues of survey reliability and sensitivity can only be viewed as secondary to the crucial consideration of survey validity. As Peryam and his colleagues stated (1960, p. 155),[112] "Reliability of results is a necessary but not a sufficient condition for meaningful research. Validity is the key. Studies well planned, well executed and skillfully interpreted may have intrinsic value, yet fall short unless their applicability to the basic problem can be demonstrated."

As noted previously, soldiers are typically surveyed as to the acceptability of food names. Instructions read, "This is not a survey of how much you like foods served in the Armed Forces. We are interested in how much you like these foods **in general**. Think of the food in a general way, rather than any particular time you have eaten it." Thus, the subject is asked to make a very abstract evaluation of each food item. Military subjects often voluntarily report that they have great difficulty trying to give a truly general rating without being influenced by the way a food is prepared in the dining hall or somewhere else. Therefore, it is debatable as to what such a rating actually means regarding food preference attitudes.

It is no wonder then that the question of validity has often arisen. How well do these abstract food preference measures, or any other measures of attitude, actually predict subsequent choice behavior? Over the past seventy-five years, a substantial literature has developed dealing with this question of behavioral validity, not only with regard to predicting food consumption but also in terms of predicting brand choice in commercial market research. Despite the amount of writings, Rokeach (1968) has said that "We are still a long way from understanding the theoretical relationship between attitude and behavior, between attitude change and behavioral change, and we have not yet learned how to predict one from the other."[122] The following brief review of recent findings about validity in commercial market research should provide some perspective for viewing the Army's work in this area.

One of the largest survey research studies on the question was undertaken by Achenbaum (1967)[1] using telephone interviews to each of 4,000 respondents. Attitude ratings and actual purchase data were gathered for 19 brands in seven product categories. He confirmed that brand usage, over groups, was related such that changes in brand rating predicted changes in behavior, that is, brand usage.

Haley and Gatty (1968) extended this work by developing a probabilistic model to predict behavioral changes (i.e., changes in a brand's share of the total product market) based on changes in hedonic brand ratings.[58] For each of their hedonic scale's six points, they computed the actual probability that part of their sample would use each brand. These predictions were then validated for several product categories by comparisons with the rest of their national sample. The changes in probability of purchase that accompanied attitude changes were called behavioral "usage weights." To predict behavior, the authors applied the appropriate usage weight to each of the six categories for each product class. The results indicated that the attitude scale data did not support an assumption of equally-weighted intervals along the six-point scale. Thus, this finding raises some question

of whether military food preference ratings obtained from a nine-point hedonic scale should be treated as equal interval data.

Using Achenbaum's as well as other data, Fothergill (1968) tested a variety of attitude measures as predictors of behavior.[35] He concluded that the best solution was to factor analyze these measures and any other available, potentially useful, variables, such as demographics. He reasoned that the emergent factor most related to behavior should suggest the attitudinal area for behavioral prediction. In fact, this accorded with commercial practice of some of the larger U.S. advertising agencies at that time. Tuck and Nelson (1968) have commented, however, that "this method is theoretically crude and practically unsatisfactory.[142] We rarely see a substantial correlation between any one factor and behavior. But it has been the best we can do."

In recent years there have been at least two substantial reviews of the literature on attitude-behavior consistency. In the first, Pinson and Roberto (1973) propose one reason for the variability encountered in studying this relationship.[115] They stress that the way attitude change and behavioral change covary may be highly dependent upon situational variables. Depending on the circumstances, one or more of these intervening variables may have a suppressing or multiplying effect on the empirical relationship between attitude and behavioral change. This notion corresponds to Rokeach's earlier (1966) statement that attitudes toward objects are only seen within the attitude toward the situation in which they exist.[121] Even twenty-five years ago, Parsons and Shils (1951) defined five situational variables to aid in the prediction of behavioral action.[108] In another survey of the literature, Gross and Niman (1975) reviewed attitude-behavior consistency in terms of "personal factors" (e.g., competing motives) and "situational factors" (social norms, number of alternatives available, unforeseen events, etc.)[45] They also considered methodological factors that may underlie attitude-behavior inconsistency. They comment, however, that "The repeated failures to demonstrate a strong consistency between attitude and behavior have had minimal impact on the assumptions and methodology of most attitude researchers."

Perhaps more attention should be devoted to such variables in administering and interpreting military food preference surveys. Can enlisted personnel divorce themselves from their attitudes toward the military and its dining halls when rating named foods? Even if some respondents can do so, the surveyor has reason to question what behavioral situation can best be predicted by these ratings.

A considerable amount of experimentation came about as a result of the development of Fishbein's model explaining behavior as a function of attitudes (1967).[33] Tuck and Nelson (1968) empirically introduced measures of "belief-strengths," as well as "behavioral intention."[142] Beliefs are interpreted as degrees of agreement with statements about a product's attributes and have many times been demonstrated as highly correlated with overall evaluation. They do not, however, enter into the present study, mainly because the large number of military foods would burden any survey with a vast number of question-items. Also, little is known to help identify the most salient beliefs for each food or the contexts in which the beliefs apply.

"Behavioral intention" does correspond in some ways to military respondents' statements concerning the desired frequency of eating each specific food, a technique first used by the military in 1950 (Polemis, 1950) and refined since then (Meiselman, Van Horne, Hasenzahl and Wehrly, 1972; Meiselman, Waterman and Symington, 1974).[117,93,94] In commercial market research Bird and Ehrenberg (1970) have been amongst those demonstrating relationships between intentions to behavioral acts and the acts themselves.[8] They have attempted to develop "lawlike" relationships between intent-to-purchase and brand share, for which one must empirically determine the appropriate coefficients for each product class.

More recently, Tauber (1975) has tested predictive validity in consumer research and determined that a number of attitudinal measures can provide deceptive information.[139] For example, one question asked respondents to state their expected frequency of use of a new product. A subsequent comparison of the "actual" use-frequency of each individual who had earlier reported as to his expected frequency revealed that consumers are poor prognosticators of their own repeat actions. Thus using such frequency estimates can be misleading. Tauber asserts again the importance of the context or situation of product behavior. In estimating repeat or continued action, he sees as very important that the product meet some unfulfilled need and that it be a satisfactory product for meeting that need. Only to the extent that both these conditions are satisfied can expected-frequency-of-use estimates serve as reliable predictors of behavior.

Bock and Jones (1968) point out that much of the study of choice behavior has been theoretical and speculative.[9] In describing the prediction of choice using real attitudinal data, their models are mostly tested by goodness of fit of the data to the model. But we are left, in general, without information on subsequent behavioral results that would validate their approaches and specific techniques.

Army studies of food preference survey validity. Army researchers have also addressed the question of predicting behavioral changes by measuring attitude changes. The major work on this topic was published by Peryam et al., in 1960,[112] followed by several other relevant papers also from the Quartermaster Food and Container Institute in Chicago. Although this literature has commonly been cited as providing substantial evidence for the validity of paper-and-pencil food preference surveys (see Meiselman, 1972; Meiselman et al., 1972; Pilgrim and Kamen, 1963; Waterman, Meiselman, Reed, Symington and Branch, 1974),[92,93,114,148] there are several reasons to question the empirical basis for this important belief.

Table I summarizes the five studies (A–E) bearing on this problem. Upon inspection, several facts emerge. First, there is a wide range of variability in the number of subjects and foods which were investigated, even among different reports about the same study. Also, it is difficult to draw conclusions given the fairly wide range (26% to 66%) of the percentages of acceptance variance explained by the paper-and-pencil preference measures. These percentages appropriately serve as the criterion measure of behavior predictability.

Table 1 . Summary of Quartermaster Food & Container Institute Food Preference and Acceptability Studies.

Study	Duration	Number of Subjects[a]	Citation	Preference Measure	Acceptance Measure[b]	Number Foods	% Variability Accounted For
A. Fts. Bliss, Monmouth, Houston, Devens 1950 - A rations	9 mos.	16 DH	Peryam et al., 1960 (Exp. 1)	Nat'l. Survey Mean Ratings	% Choosing	46/60	35
B. Fts. Sill, Monmouth, Belvoir, Benning, Knox 1951 - A rations	9 da.	50 DH	Peryam et al., 1960 (Exp. 2)	Nat'l. Survey Mean Ratings	% Consumed	107/212	38
C. Pole Mtn. Wyoming 1953 - Restricted B & C rations Cold weather	1 mo.	86 men	Peryam et al., 1960 (Exp. 3)	Subjects' Survey Ratings of Fds. (Day 9)	% Consumed	37/41	48
	5 wks.		Schutz & Pilgrim, 1958	Subjects' Survey Ratings of Fds. (Days 9 & 37)		41	48-66
D. Ft. Carson 1955 - Modified A rations Ad Lib (quantity)	1 mo.	100 men	Peryam et al., 1960 (Exp. 4)	Subjects' Survey Ratings of Fds. (Week 4)	% Choosing % Consumed	38/150	59 54
		91 men	Schutz, 1957	Subjects' Survey Ratings of Fds. (Wks. 2,4)	% Choosing & % Consumed	54/150	26-59
		100 men	Vawter & Konishi, 1958	N/A	% Choosing & % Consumed	170	N/A
E. Four Army Posts (CONUS) 1958 - A rations	1 mo.	5-60 DH	Kamen, 1962	Nat'l. Survey Mean Ratings	% Choosing % Consumed	105/160	39 36
			Pilgrim & Kamen, 1963		% Choosing	160	31

[a]DH = Dining Hall
[b]% Choosing = percent of individuals choosing that food
% Consumed = percent of serving eaten

Therefore, any conclusion about the validity of food preference surveys must await a detailed examination of these studies to explain the apparent inconsistency of their results. Some general considerations first need to be reviewed.

Depending upon the adequacy of the research design and methodology, several unwanted factors can influence the outcomes of food preference studies. First, investigators should decide upon explicit criteria before selecting the food items, subjects, and rating scales to be used. Any post hoc selection may result in experimenter bias, especially when the reasons for discarding data are not specified. A second source of error can result from the operation of uncontrolled variables during the measurement of behavioral choice. Typical examples are frequency of serving, appetite level, pressure to consume what is chosen, and the number of foods available for selection. Another source can be the behavioral acceptance measure. In some studies this corresponds to the amount of plate waste, which is taken to indicate the proportion of food consumed. This measure is likely to be confounded with the extent of overpreparation and portion size, especially if only total plate waste is measured. When the acceptance measure is the percentage of subjects choosing a food, bias can result from not equating the availability of each food item nor controlling for hedonic and compatibility differences within the choice-arrays of foods available at each offering.

The operation of these unwanted factors can have different effects upon the index of behavioral validity, that is, the correlation between stated preference and actual choice or consumption. Some factors will inflate the true correlation, or make the relationship appear stronger than it really is. Examples might be experimenter bias involving the post hoc selection of certain foods for subsequent correlational analysis or pressure put on enlisted subjects to consume everything they choose when plate waste is being recorded. If the dependent measure is the percentage of subjects choosing an item, inflation can result from serving relatively few items which are primarily either liked or disliked greatly.

Other factors may operate to deflate the true correlation, or make the relationship appear weaker than it really is. This can occur when overpreparation and plate waste are confounded with the actual proportion of food consumed, thereby masking the true relationship between stated preference and actual behavior. Even if the percentage of food consumed is accurately measured, there is reason to believe that this measure relates poorly, if at all, to the more meaningful measure of percentage of subjects choosing an item (Kamen, 1962; Vawter and Konishi, 1958).[76,144] The latter measure has been shown to be more sensitive to acceptability differences among foods and to be much more reliable across different sample groups. Thus, even the correct use of the percentage consumption measure would be expected to deflate the true correlation between stated preference and actual preference behavior. Deflation may also occur when a factor, such as the increased frequency of serving certain items, operates to increase the variability of recorded choice behavior.

The possible influence of all the various biasing factors becomes apparent when considering the studies (A–E) summarized in Table 1.

Study A was conducted at four different Army posts during 1950 and appears to have fewer limitations than the studies which followed; however, very little information is available regarding the methods of data collection used in this first investigation. To measure acceptance the experimenters periodically recorded the percent of soldiers choosing a given food at four dining halls at each of the posts during nine months. Although they measured the acceptance of 60 foods, they were able to obtain mean hedonic ratings for only 45 of them based on the approximately 2000 subjects in the national survey. There is no indication as to the identity of, or the basis for choosing, the 60 foods to study and thus no evidence that their acceptability was either less or more predictable than that of others not chosen. It is reported, however, that the frequency of serving, i.e., availability, varied from one to thirty for individual items. As others have shown (Schutz and Pilgrim, 1958; Siegel and Pilgrim, 1958; Vawter and Konishi, 1958),[127,132,144] frequency of serving has a definite effect upon the acceptability of different foods, with increased frequency lowering the preference for some more than others. The uncontrolled nature of this variable could be expected, therefore, to increase the variability of the choice data thereby deflating the correlation and underestimating the strength of the preference-choice relationship. The problem of uncontrolled serving frequency is also present in studies B, D, and E described in Table 1.

The acceptance measure used in study B is the percentage of food consumed based on the percentage of total waste for 212 foods. A high potential for measurement error is present because total waste included both waste from *overpreparation* and plate waste which can be affected by variations in portion size. The authors state that "- - - they had reason to believe that the foods served during the study were of better than normal quality and that direct or indirect orders were issued to the soldiers to minimize waste," (Peryam et al., 1960. p. 61).[112] They go on to say that this situation would tend to increase the intake of less preferred items and thereby result in a deflated estimate of acceptability. An alternative interpretation, not considered, is that subjects may have avoided items they were unsure they wished to finish, i.e., low-preference items, while eating more of the medium-preference items which were of better-than-usual quality. The result would be to increase the measured correlation between hedonic ratings and the acceptance measure. Conversely, the inclusion of over-preparation waste may have acted to deflate the true correlation estimate if overpreparation was distributed randomly across all food items or was more likely to occur among foods well liked. Regardless, the results may be seriously questioned as to their usefulness and general applicability, especially when compounded with the uncertain identity between some preference survey items and the actual items served (see Peryam et al., 1960, p. 62).[112]

Study C took place at Pole Mountain, Wyoming, and is limited in the same way as Study B in terms of measuring acceptance by the percentage of food consumed, although here only plate waste was counted. A more serious problem of generalizability stems from the fact that the study was conducted in conjunction with a cold weather performance

test using restricted canned rations. Subjects were repeatedly served fixed amounts from four daily menus of 41 total foods. An hedonic preference survey based only on the 41 foods available was administered twice during the five and one-half weeks of the study, on day 9 and on day 37. Thus, the subjects had already completed two of the 4-day menu cycles when first surveyed.

The two reports based on this study examine the data differently. Peryam et al., (1960) analyzed only the first four weeks, giving no reason for excluding the last week.[112] They report only on prediction of acceptability by the first set of preference ratings, claiming that these were less likely to be influenced by the repetitive feeding. The authors warn that the relatively high degree of reported predictability (48%), as well as that reported for Study D, may be due to the subjects' familiarity with the rated foods. Indeed, one might expect predictability to be highest when test foods are few in number, highly familiar, and the only ones available under isolated circumstances. As available foods increase in number and vary more widely in familiarity, and as supplementary foods become accessible, as is characteristic of the normal garrison feeding of troops, the variability of the consumption measure will increase, and the correlation between preference and consumption will decrease. The Peryam et al., estimate of 48% of common variance may represent an upper limit for the predictability of consumption from preference ratings.

Schutz and Pilgrim's (1958) analysis of the same study is enlightening in that it demonstrates the effects of repeated food exposure on consumption and preference, but it too is subject to many of the limitations just discussed.[127] The consumption data were divided into three periods (days 1 to 9, 10 to 37, and 25 to 33), and each were correlated with the two sets of survey preference data for each food item (days 9 and 37). The authors only report the range of predictability (48 to 66%) but include all 41 foods served, whereas Peryam and his colleagues only reported the results for 37 foods.

Repeated exposure was found to significantly reduce the preference rating for most low preference items, especially meats and vegetables. It is difficult to interpret how this monotony factor affected predictability because corresponding consumption changes are not included in the results. It would be helpful to know how predictability varied for each item across the six preference-consumption correlations. If, as Peryam et al.'s (1960) report suggests, predictability was greatest for the correlation most likely to be affected by repeated exposure (i.e., preference data from day 37 correlated with consumption data from days 25 to 33), then only the lower portion of the range should be considered as generalizable to normal garrison feeding.

The interpretation of the correlations derived from the Pole Mountain data is further complicated by the potentially strong effects of cold weather and high physical activity on food preferences and eating behavior (see Brozek, 1958; Pilgrim, 1957).[15,113] It is possible that these factors may have acted systematically to increase food likes and dislikes or to increase preferences for all foods.

The Fort Carson study (D in Table 1) also presents several dilemmas of interpretation, especially when the various reports it generated are compared. As in analyzing other studies, Peryam and his colleagues (1960) were selective in choosing the foods and measures to be analyzed.[112] Of the 150 foods served during the four weeks, only 54 comprised the special preference survey administered during the second and fourth weeks to the subjects, and only 38 of these were eventually analyzed. Also, the second rather than the first survey was used to predict acceptability (59% predictability for percent choosing and 54% for percent consumption). The familiarity of the subjects with both the foods and preference survey by the time of the second survey would maximize the computed correlation of preference with acceptance because subjects' ratings would be greatly affected by the prior four weeks' eating experience (see Pinson and Roberto, 1973).[115]

Schutz (1957),[125] in examining the same data, analyzed all 54 foods surveyed, using both sets of preference ratings, but only for 91 of the 100 subjects. He reported the range of correlations for the consumption and choice of different foods 26 to 59%, the highest being equal to that cited in Peryam et al. The discrepancies between the two reports concerning both the number of subjects and foods analyzed deserve some explanation before any ultimate conclusions can be drawn about the reported predictability of acceptance behavior.

The report by nutritionists Vawter and Konishi (1958) further confuses interpretation of the Ft. Carson study by listing still a different number of foods served (170) and stating that they found "- - - little relationship between acceptability (% subjects choosing an item) and the proportion of the food taken which was consumed (p. 39)."[144] The use of "proportion consumed" as a measure of acceptance, in this and the prior two reports, is questionable since there was no limit on the amount that could be taken; a more appropriate measure would be absolute quantity consumed. They found that the acceptability of some foods was highly dependent on the presence of certain other foods at the same time (see also Kamen, 1962),[76] a factor that lessens the predictability of choice behavior from stated preference.

The final study (E) listed in Table 1, was conducted at four large, geographically dispersed posts where two dining halls were surveyed each day for all three meals over a month's time. In many ways it resembles study A in that different dining halls were studied on different days, frequency of serving varied for different foods (see above), and the number of behavioral acceptance measures per food varied from 122 to over 2000. Kamen (1962),[76] in reporting these data, correlated the available national preference survey ratings with acceptance for 105 of the 160 available foods. He reports a common variance of 0.39 for the percent choosing those foods, very close to the 0.35 reported for study A.

As Peryam et al. (1960) found for study B,[112] accuracy of acceptance prediction depends on food class; however, Kamen found high predictability for different classes than Peryam and his colleagues reported. They had stated that predictability was highest for those food types that are more "dispensable" in a meal, such as desserts, whereas Kamen reported that desserts are lowest in predictability and vegetables highest. Overall predictability was 39% for the percentage of subjects choosing an item and 36% for the percent of the serving eaten.

When Kamen compared the average percent choosing and percent consumption values found in his study with those found in study A for 75 common foods,[76] he discovered that the correlation for either index was about 0.50 as compared to the 0.95 to 0.99 correlations reported for mean preference ratings for foods repeated in successive surveys (Peryam et al., 1960: Waterman, Meiselman, Branch, and Taylor, 1974).[112,147] Thus, behavioral acceptance indices are much less stable than preference ratings for similar subject populations. He also found that the percent eaten of a given food item was less reliable (r = 0.38) across different installations than was the alternative acceptance measure of the percent of individuals choosing an item (r = 0.95). Kamen concluded that the percent-choosing measure is more sensitive in that it better differentiates foods than the alternative percent of food eaten,[76] but that neither is as generalizable across time as the national preference survey ratings. The greater variability of the percent consumption measure suggests that its value is primarily determined by fluctuations in food quality and portion size which can vary greatly over days and installations. Consequently, while preference ratings may reflect time-related changes in group food preference attitudes, they appear to bear little relation to concomitant changes in the behavior they are intended to predict.

Pilgrim and Kamen (1963) treat this final study in a different manner.[114] They used the Army percent choice acceptance data from all 160 foods to examine the predictive value of several subsequent psychological and nutritional measures. Four hundred airmen were asked to rate 72 different foods on four scales: preference, desired frequency of serving, satiety or "fillingness" and quality of preparation. The authors then computed the correlations for predictability of choice behavior; however, they reported results only for the airmen's "fillingness" ratings, ignoring the other three scales. Then they proceeded to determine predictability from preference ratings, using the results from the national survey (N = 2000). Notice in Table 1 that this figure, 31%, is lower than the 39% Kamen (1962) reported for the same study using the same national survey ratings for his 105 foods.[76] It is difficult to understand why the authors reported predictability of choice based on the fillingness scale but did not report the same measure based on the three other scales, including a preference scale, choosing instead to use ratings from a national survey. Both "fillingness" and the log caloric density of foods predicted a greater percentage (50% and 43%, respectively) of the variance in choice behavior than did their selected preference measure.

In conducting validity work, the issue of predicting the behavior of groups versus that of individuals must also be addressed. As was mentioned earlier, there is already an indication, (Waterman, Meiselman, Branch and Taylor, 1974) that test-retest reliability of individuals' preference ratings for a set of foods is much lower than the between-subjects reliability for the mean ratings for various foods.[147] Smutz et al. (1974) made an initial attempt to examine whether the results of group studies are representative of individual attitudes and behaviors.[134] They report a median rank-order correlation of 0.50 or 0.44 of preference with percent choice of food, depending on whether the preference ratings were given before or after the consumption test. This report can only be considered preliminary, however, because it involved only ten subjects for five days (10 meals) and did not control for frequency of serving or for combinations of available foods. It is unfortunate that the authors of studies C and D in Table 1 did not analyze their individual preference and consumption data by subjects in addition to their group analysis.

In summary, the earlier work which has been frequently cited to justify the validity and meaningfulness of preference survey data is questionable and lends only modest support as justification for collecting such ratings. The discrepencies, possible sources of bias, and inappropriateness of some of the measures, lead us to the conclusion that additional validity studies must be run before a sound judgment can be made regarding the value of stated preference ratings. As Smutz et al. stated on the first page of their 1974 study, "If there is high concordance between results on the preference scales and actual food choice, then one is highly justified in using the scales to help in menu planning. But if the relationship is low, then the use of hedonic and frequency scales in menu planning should be seriously reconsidered."

Method

A total of 14 male and 11 female subjects participated in various portions of the experiment (see Appendix A–2 for specific ages and sexes). Six of these subjects were studied under the auspices of the Department of Medicine, New Britain General Hospital, New Britain, Connecticut, and consisted of hospital staff physicians, laboratory technicians, and a local physical scientist. The remaining subjects were studied by the staff of the Chronobiology Laboratory, University of Minnesota School of Medicine, Minneapolis, Minnesota, and consisted primarily of undergraduate students and a few laboratory technicians. All subjects were thoroughly briefed on the requirements of the study and then asked to sign a consent form testifying to this fact and to the voluntary nature of their participation (see Appendix A–3). Only the Undergraduates received a small stipend ($400) for completion of the study, all others were unpaid volunteers. Aside from performing self-measurements and recording their food consumption, all participants carried out their normal daily routines throughout the course of the study.

Every attempt was made to carry out this study on each subject in accordance with the general design considerations outlined in Figure 1; however, this was not always possible primarily due to subject and ration availability. Therefore, throughout the entire

study, different data analyses often include different subjects. Nevertheless, each analysis includes all subjects for whom appropriate data exist. A detailed record of the preference surveys and food consumption conditions which each subject underwent is available in the appendices (A–1 and A–2). It should be noted that many of the Minnesota subjects were forced to halt their participation at the end of Stage IV on 12 November 1974 due to an unavoidable delay in the arrival of a ration shipment. They resumed the study on 13 January 1975 by first repeating Stage IV and its associated ration-specific preference surveys. Several additional new subjects also joined the study at this time, bypassing Stages I to III.

Except for Stage I, all food consumption was restricted to two types of military rations. One set consisted of 12 menus of canned foods referred to as Meal Combat Individual (MCI) rations which the Army has used to replace the well-known C-rations. The other set consisted of all 8 meals of the U.S. Air Force precooked frozen rations, each packaged in a standard, disposable aluminum tray. The components of each set of rations are listed in Appendices B–4 and B–5. Their nutritional contents were determined by laboratory analysis and are described in Appendices C–4 and C–5. A third type of military ration was used for only the first three days of the study (Stage I). These were dehydrated Long-Range Patrol (LRP) rations which could be reconstituted by adding hot water. Because of insufficient supplies, LRP use was discontinued, and the corresponding data of Stage I is therefore not included in this report, nor in Figure 1.

As part of the initial screening of each subject, the U.S. Army Natick Laboratories 1972 General Food Preference Survey (GPS – see Appendix B–1) was administered in which 378 food items were rated as to "How much you like or dislike" each food (using a 9-point hedonic scale ranging from 1: dislike extremely to 9: like extremely, with 5 being neutral) and "How often you want to eat" the food (in days per 30-day month). This survey was intended to determine how much the various foods were liked in general, in view of the subject's previous experiences. The GPS was again administered at the end of Stage IV and Stage VI for most subjects.

In addition to the GPS, ration-specific food preference surveys (SPS's) were also used. Their format was identical to that of the GPS, but they were based solely on the actual ration foods offered in each stage. These surveys were administered both before and after a smorgasbord which was offered before Stages I, II, and III in which the specific military ration foods were first tasted. A third SPS was completed at the end of each stage. Thus, all subjects filled out a LRP ration SPS before and after a smorgasbord of LRP menus and again at the end of Stage I. During Stage II those subjects assigned to only frozen food filled out a Frozen Food SPS (Appendix B–5) at the appropriate three times, while the other subjects assigned to eat only canned food during Stage II filled out a MCI SPS (Appendix B–4). During Stage III the two groups switched food types and filled out the appropriate food surveys before and after the smorgasbord and again at the end of the two-week stages. At the beginnings and ends of Stages IV, V and VI, both the MCI and Frozen food preference surveys were supposed to be administered

to all subjects since both food types were offered; unfortunately, some surveys were inadvertently skipped by certain subjects. Further details regarding the exact occurrence of the GPS's and SPS's for each subject are available in Appendix A–1. Subsequent statistical analyses of the preference data include all available results appropriate to the question being addressed.

In addition to the foregoing food preference surveys (General and Specific) two other food preference questionnaires were administered during Stage IV. These were circular triad tests designed by Dr. Darwin Hendel of the University of Minnesota Survey Research Center to determine which menu in a set of pairs of canned or frozen foods was preferred (Appendices B–6 and B–7). One questionnaire contained all possible combinations of pairs of canned menus while the second questionnaire offered a choice between all possible pairs of frozen food menus. The subject had to circle the preferred menu in each pair.

During the **ad libitum** portion of the study (Stages II to IV), subjects were allowed to eat as much and as often as they wished as long as they restricted their food choices to the available military rations appropriate to that two-week stage (see Figure 1 and Appendix A–2 for details). Mealtime restriction was imposed during Stages V and VI for the experimental subjects (N = 17) while the control subjects (N = 6) continued eating **ad libitum.** For three weeks those subjects assigned to the big breakfast condition were instructed to begin eating within an hour after awakening and, if possible, to complete their meal within an hour's time. Although they were required to consume almost all their daily calories as breakfast, there were no restrictions placed on the amount or type of ration foods that could be eaten. The subjects assigned to the big dinner condition were given the same instructions except that the day's calories had to be consumed in a one-hour meal during the late afternoon or early evening. On the day of transition from the dinner to breakfast condition, or vice versa, they could eat twice but preferably more at the new time.

Subjects were required on their honor to keep accurate records, in terms of when, what, and how much they ate. A copy of the general instructions is provided in Appendix A–4. An instrument called "Daily Food Log", designed to provide a complete listing of a subject's daily food and beverage consumption (see Appendices C–1, 2, 3), served this purpose. For the sake of accuracy, each subject was asked to fill in the required information immediately after finishing each meal or snack. Each food item was written out and given a coded number as well. Next to the item eaten, the subject recorded the clock hour and the amount left (to the nearest gram) of any remaining food item selected for eating but not completely consumed. A dietary scale was calibrated for accuracy and provided for this purpose. If the item was completely consumed, a value of zero was entered. The item then was rated as to taste using a 9-point hedonic scale ranging from "like extremely" (9) over "neither like nor dislike" (5) to "dislike extremely" (1). The subject also indicated whether the food was eaten alone (0) or in the company of others (1), where the food was eaten (home = 0, work = 1, other = 2), the pace at which the food was eaten (leisurely = 1, moderately = 2, hurriedly = 3) as well as rating the degree of hunger experienced before beginning a meal or snack, using a 5-point scale ranging from "not hungry" (1) to "extremely hungry" (5).

In addition to the foods provided, subjects were permitted to consume white bread, margarine, coffee, tea, low-calorie milk and soft drinks and to use an artificial sweetener, if desired. These items were also recorded on the Daily Food Logs by name, e.g., type of beverage, time of drinking, and number of 8-ounce cups taken. Bread consumption was recorded as to time, number of slices, and whether or not margarine was used. If a subject ate the same food item two or more times on the same day, the item was either entered at the bottom of the Daily Food Log or on an additional Food Log for that day.

Each subject was required to have available at all times at least two of each food item to allow free choice for all items whenever eating. In order to accomplish this, each subject took a supply of foods home and replenished items as needed from the main stockpile kept at the laboratory. Subjects cooked their own food either at home or at facilities in the laboratories, following the instructions provided (see Appendix A–4). Throughout the experiment, participants were encouraged to break up any mealpack and eat only what was desired and to eat whenever and as often as they wanted except when mealtimes were restricted during Stages V and VI.

Results and Discussion

Are the questionnaire items reliable in test-retest situations? This question was not posed as an explicit objective of the experimental plan. Nonetheless, it is an extremely important one that deserves careful understanding and reasonably complete definition. At the same time we recognize that reliability must be assumed in the conclusions which follow from these experimental data. Hopefully, future experimentation will be designed to more thoroughly examine the reliability question.

Reliability may be considered from several points of view. One may consider test-retest reliability of the items within subjects or among subjects. Also, certain items may be relatively reliable and others less so. Averages for the various food classes (appetizer, entree, dessert, etc.) may be more or less reliable than for other food classes. There may be high reliability using the same sample of subjects in the retest but low reliability when a new random sample of subjects is selected for the retest. Such reliability may differ with different sub-groups of the population, as with different levels of literacy or education. Consistency may be seen as one aspect of reliability: individuals may each be consistent from test to test but there may be considerable variability from person to person for an individual item, for a food class, or for most foods. It is unfortunate that with the present data there is no satisfactory way of examining these issues free of other influences such as recent food-choice array, mealtime restrictions, and eating experience.

To the extent that preference ratings are affected by recent food experience, it is virtually never possible to conduct identical retests after the passage of time and the eating experience that accompanies it. The passage of time, and particularly recent eating

experience may affect responses concerning both the available foods and food items not included in the menu. While these issues are to be discussed in a later section of the report, they may be confounded with the questions concerning test-retest reliability.

Finally, all of these questions should be considered in the light of both preference rating scales, the hedonic rating as to the degree liked (1 through 9) and the frequency desired (0 through 30). For the moment, we will consider the possible redundancy of these two types of preference measurement items.

Are the two rating scales really measuring different aspects of preference? One might think that if a food is given a high hedonic rating that it would be desired frequently, at least in most cases. This appears to be true in studying the correlations between each person's main entree hedonic and frequency ratings for all Specific Preference Surveys administered (Table 2). For most of the people, most of the time, there was considerable redundancy between the two measures. Most of the subjects (13/23) never had a correlation coefficient less than 0.7, though as many as five coefficients were computed for each person, covering the various stages of the experiment. Of the ninety-one coefficients computed, only nine were less than 0.6, and a single subject (No. 61) accounted for almost half of them. That subject had a high correlation of 0.93 on the first post-smorgasbord SPS questionnaire and much lower correlations in later SPS tests.

By the time subjects were quite familiar with the food and with the SPS questionnaires, that is after Stage IV, the correlations between hedonic and desired-frequency ratings were virtually all consistently high (except for subject No. 61): even including that deviant subject, with his low correlations, we find a median correlation coefficient of 0.81 among that set of 41 coefficients computed. Ratings given after two weeks experience of eating the foods (after Stage II or III and before Stage IV) resulted in a median correlation of 0.83 between the hedonic scale and the frequency-desired scale. Eating experience then appears not to affect the median correlation, which is quite high.

Most interestingly though, a very high median correlation of 0.91 is found just after the smorgasbord that familiarized the subjects with the foods but before they had any prolonged experience with them or with the arduous task of filling out questionnaires so many times. While the median correlation was very high, we find at this stage just four subjects who exhibit little or no correlation between their hedonic ratings and their desired-frequency ratings for main entrees. All four of those subjects showed much higher correlations in later tests. We may affirm then, a rather consistently high correlation between the two preference measures. More information will be provided on this subject when we consider to what degree these two preference measures actually predict food-choice behavior, and consider the relative importance of each of the two measures.

To what extent are overall preference ratings for frozen dinners explained by preference ratings for each frozen menu component? In this study, the frozen ration items were all components of meal packs. The SPS questionnaire asked the subject to

Table 2 . Correlation Coefficients Between the Hedonic and Frequency Ratings for Main Entrees on the Specific Preference Surveys

	After Smorgasbord (SPS 7 or 8)		After Stage II or III (SPS 10+12 or 9+11)	After Stage IV (SPS 15+16)		After Stage V (SPS 18+19)	
Subject	Canned	Frozen	Canned & Frozen	Canned & Frozen		Canned & Frozen	
1	--	--	0.87	(0.87)	D	0.79	B
2	0.61	0.74	0.84	(0.84)	B	0.79	L
3	0.92	0.91	0.91	(0.91)	A	0.88	A
4	0.98	0.96	0.92	(0.92)	D	0.61	B
5	0.94	--	0.67	(0.67)	B	0.76	D
6	0.91	0.80	0.84	(0.84)	A	0.94	A
51	0.10	0.92	0.77	0.80	B	0.93	D
53	0.83	0.84	0.76	0.89	D	0.67	B
54	0.90	0.90	0.77	0.80	B	0.79	D
55	0.74	0.78	0.43	--		--	
56	0.91	0.85	0.85	0.90	A	0.90	A
57	0.90	0.52	0.84	--		--	
58	0.84	0.12	0.91	0.76	B	0.76	D
59	0.37	0.83	0.78	0.72	B	0.74	D
61	0.19	0.93	0.51	0.50	D	0.59	B
62	0.91	--	0.73	0.84	D	0.78	B
63	0.90	0.73	0.74	0.90	A	--	A
64	--	0.99	0.84	0.83	B	0.97	D
66				0.83	B	0.71	D
68			0.90	0.81	D	0.83	B
69				0.79	D	0.82	B
70				0.78	A	0.84	A
71				--	D	--	B
72				0.64	B	0.80	D

Notes: Parentheses indicate that SPS's 15 & 16 not available, substituted most recent SPS.
A, D, and B indicate Ad Lib, Dinner only, or Breakfast only regimen, respectively.

rate the meal-pack dinner as well as each component item. Thus, it is possible to examine what percentage of variation in meal-pack ratings was attributable to each of the component items, or to each of the food classes (main entree, vegetable, starch). Using multiple regression to explain the overall ratings for the meal-packs, we could interpret the standardized regression coefficients as measures of relative importance; however, these calculations have not yet been carried out.

An additional check on the conclusions might be done by using the paired-comparisons ratings of frozen meal-packs and regressing them against the SPS ratings of the meal-pack component items.

While these calculations cannot be completed in time for this report, we recognize the opportunities provided by the data. At the same time we take cognizance of the previous work done on this type of question. Eindhoven and Peryam reported on the measurement of preferences for food combinations (1959a) and on the compatibility of menu items (1959b).[26,27] Eckstein studied menu planning by computer (1967) and Balintfy devised an IBM 360 computer program for computer-assisted menu planning (1969). In an unpublished and undated manuscript, a new theoretical approach was taken by Moskowitz, Klarman, and Wehrly.[96] These authors had 150 subjects rate five meats, five vegetables, and five potatoes, using a magnitude estimation scale (described in Moskowitz and Sidel, 1971)[98] applied to food combinations in pairs and triples. They applied multidimensional scaling and derived a three-dimensional space of food compatibility. Ultimately they developed a "compatibility index" for each of their fifteen foods and considered the overall acceptability of a menu as the linear sum of the component compatibility values. Without much more empirical work, one might not accept such an assumption. But their work is a point of progress in our efforts to assess the role of individual food items in the overall acceptability of a menu.

Are paper and pencil preference ratings affected by the questionnaire format? A subset of the General Preference food names corresponds reasonably well to items on the Specific Preference Survey questionnaire, especially in the case of frozen ration items and some of the canned fruits. The food names are rarely identical but their close similarity suggests that any major difference in ratings between the two surveys would be due mainly to location of the item in the questionnaire and the length of the questionnaire.

There is some concern as to how stable item ratings are, independent of their context in any one form of food questionnaire. The GPS instrument will undoubtedly be modified in the future by the addition or subtraction of certain items and by the use of variously arranged, shortened versions of the total food list, especially for the purposes of specific experimentation. If item ratings are extremely context-dependent, varying with the format and length of the questionnaire, there would be little usefulness for the large data bank of norms built up from the history of previous surveys.

To answer the question of context dependency there are two occasions at which most respondents completed both GPS and SPS questionnaires: before any exposure to the experimental foods, and at the end of the study. The earlier occasion offers a somewhat better comparison. After the experiment there were varying time lags before all the subjects completed both the survey forms, so only the first occasion is used in the analysis here. For both the hedonic and frequency ratings, analyses of variance reveal statistically significant differences between the surveys and among the foods and indicate a significant interaction between the foods and the surveys (see Appendix G–5 for the ANOVA summary).

Nevertheless, there is a reasonable correspondence of ratings between the two survey contexts for the individual food items. The statistically significant differences are not so much due to any large differences among the ratings themselves but are due rather to the high power of the statistical test, and to the generally higher level of ratings given on the SPS questionnaire form.

Averaged over the 22 food items, SPS ratings are 0.25 higher for the hedonic rating and 2.0 higher for the frequency ratings. The higher ratings are quite consistent over the set of food items. The SPS average hedonic rating exceeds the GPS average for all but six of the 22 items. In the case of frequency ratings, the SPS is higher for all but three of the items (Table 3).

Despite the statistically significant interactions between foods and surveys, the average rank order preferences for the food items are reasonably similar between the two surveys. Changes in relative preferences among foods typically resulted from differences of no more than 0.3 points on the hedonic scale or 1.0 points on the frequency scale. One conspicuous inconsistency (Roast Pork) ranks fourth on the GPS hedonic rating and ninth on the SPS, among nine main entrees. But in the SPS this is a canned item, the only canned meat item usable in our comparison here, and one that goes by the food name "Pork, slices, juices," only barely comparable to the SPS food name "Roast Pork."

During further, more detailed analyses, individual subject ratings might be examined for comparability. From the average results here, however, we may tentatively conclude that there seems to be no obvious major problem created by changing the exact format or length of the questionnaire, or even of modifying the food names slightly. Ultimately, when this question is studied thoroughly, it will be done with a background documentation of the reliability of the General Preference instrument and its items. The various aspects of reliability are discussed in a prior section.

Does continued exposure to specific foods affect preference ratings for those specific foods? Data from the SPS tests provide a different point of view than the GPS tests. With the Specific Preference Surveys, the names of the foods on the questionnaires correspond exactly to the labels on the specific foods. The first time subjects take the SPS (test 5 for canned food, test 6 for frozen food), the food names are only food names;

Table 3. Mean Hedonic and Frequency Ratings for Common (Ration) Foods on First General and Specific Preference Surveys.

Food Item	Hedonic GPS	Hedonic SPS	Frequency GPS	Frequency SPS
Entrees†				
F - French Fried Shrimp	8.06	8.39	14.78	16.52
C - Spaghetti w/Meat Sauce	7.87	7.74	14.00	12.39
F - Roast Turkey	7.78	7.83	9.04	12.48
C - Roast Pork	7.22	6.48	8.75	8.52
F - Salisbury Steak	7.04	7.48	9.55	12.65
F - Omelet	7.04	7.17	10.74	12.43
F - Ham	6.95	6.56	9.73	9.78
F - Swiss Steak	6.86	7.35	8.39	11.43
F - Sausage Links	6.64	6.83	9.37	10.00
Starches				
F - Mashed Potatoes	6.91	6.65	12.56	11.00
F - Steamed Rice	6.78	7.70	8.91	14.61
F - Buttered Noodles	6.38	6.65	7.71	11.09
F - Sweet Potatoes	5.22	5.78	6.74	7.52
Vegetables				
F - Frozen Green Beans	6.02	6.09	7.50	8.48
F - Frozen Peas	5.75	5.65	7.15	7.96
F - Mixed Vegetables	5.56	6.26	5.91	9.30
F - Peas and Carrots	5.53	5.52	6.57	6.65
Fruit				
C - Canned Peaches	6.96	7.78	8.39	13.96
C - Applesauce	6.95	7.30	8.66	11.64
C - Canned Pears	6.61	7.48	8.52	12.78
C - Fruit Cocktail	5.87	6.52	7.61	11.48
C - Canned Apricots	5.75	5.96	5.68	7.61
GRAND MEAN	6.62 *	6.87	8.92 **	10.92

* $p < 0.05$
** $p < 0.025$

†F (Frozen) and C (MCI) indicate SPS source of rating; in cases where item appeared twice in GPS, the rating for first occurrence was used for analysis.

subjects have not yet seen the specific ration items. Ratings must be based on general prior experience and abstract mental image. After the smorgasbord, a buffet-style exposure to our specific rations, the SPS ratings (test 7 for canned, test 8 for frozen foods) might be considerably influenced by the subjects having seen and tasted them. Verification of this hypothesis remains untested for the time being.

The question as to the effect of continued exposure can be answered, however, by comparing post-smorgasbord ratings (tests 7 and 8) to SPS ratings after two weeks of experience with each of the two SPS rations, the canned and the frozen rations.

The effect we see is a moderate decline in both the hedonic ratings and the frequency desired, for both canned and most frozen rations (see Tables 4 and 5). It is a small decline that applies consistently to all classes of food (entree, starch, vegetable, canned fruit, and desserts). Canned foods declined in preference slightly more than frozen foods, approximately one-half a hedonic unit and 2½-days frequency, contrasted to less than ¼ hedonic unit and one day frequency.

Within food classes, the slight decline is reflected quite consistently over virtually all foods; no item increases in average hedonic rating by as much as 0.5, or in desired frequency of serving by as much as one day per month -- with the single exception of sliced apples. Smaller increases in hedonic preferences developed for all egg entrees, both for the frozen omelets as well as canned ham and eggs.

We had expected that at least a few foods would show great declines in preference given the fact that the main entrees were so limited in number (8 frozen dinners, 12 canned entrees). But two weeks of experience do not reflect this. Apparently the choice array was large enough to offset extreme boredom, and subjects were able to introduce variety in the preparation of the foods.

It might be instructive, at a later date, to compare SPS ratings from the very beginning of the experiment to the very end in order to assess longer-term exposure with the exact same set of subjects throughout. With the data at hand, however, the indications are clearly toward a further decline in ratings by the end of another fortnight: by the end of Stage IV, for both canned and frozen rations, the hedonics and frequencies have fallen substantially. Except for three people, the set of subjects used in this later comparison is identical. Hedonics for both canned and frozen foods have dropped by almost one hedonic unit and desired frequencies have fallen by more than three and a half days per month. The decline seems more due to a general erosion of ratings, rather than any spectacular declines for specific food items. We are tempted to suggest that subjects might be bored with the survey questionnaires as much as with the ration foods. By the end of the experiment they have endured hundreds of repetitious test questions and months of rigorous self-discipline imposed by the experimental design. Maybe the respondents are just tired of it all (see Appendix H for a summary of verbatim comments).

Table 4. Mean (N=11) SPS Preference Ratings for Canned Rations Before and After Two Weeks of Canned Ration Experience (Stage II or III)†

Entree		Hedonic Before	Hedonic After	Frequency Before	Frequency After
Beans w/Franks		6.82	6.45	6.91	5.73
Ham & Eggs		5.55	5.64	6.09	4.82
Beans w/Meatballs		6.55	6.64	8.18	7.54
Turkey Loaf		7.91	7.09	11.36	9.54
Ham, sliced		6.55	6.55	8.73	7.09
Beef Steak		6.82	6.36	8.45	7.09
Spaghetti/Beef		7.55	7.00	11.27	8.82
Beef w/Sauce		6.91	5.82	9.82	6.45
Chicken or Turkey		7.73	7.55	12.91	9.64
Beef Slices		6.64	5.91	8.36	7.54
Pork		6.45	5.91	7.18	5.82
Tuna Fish		7.73	7.36	13.82	9.82
	Mean	6.93	6.52	9.42	7.49
Canned Fruit					
Pineapple		7.36	6.45	12.18	7.33
Apricots		7.45	7.00	13.54	11.09
Fruit Cocktail		8.27	7.55	16.82	12.73
Fruit Cake		7.00	6.09	10.54	6.91
Pears		8.27	8.18	19.09	15.27
Peaches		8.36	8.09	19.18	18.27
Apple Sauce		7.91	8.09	17.00	12.45
	Mean	7.80	7.35	15.48	12.01
Dessert					
Sweet Choc. Disk		7.27	7.64	14.18	14.91
Coconut Disk		6.55	6.45	9.27	7.82
Choc. Nut Roll		7.45	6.91	12.54	10.36
Choc. Fudge Disk		6.55	6.36	11.09	7.45
Vanilla Disk		6.27	5.18	8.00	3.73
	Mean	7.02	6.51	11.02	8.85
Crackers		7.18	6.73	20.54	15.27
	Grand Mean	7.16	6.76	11.88	9.34

†Before = SPS 7, After = SPS 9 or 12.

Table 5. Mean (N=11) SPS Preference Ratings for Frozen Rations Before and After Two Weeks of Frozen Ration Experience (Stage II or III)†

		Hedonic		Frequency	
		Before	After	Before	After
Entree					
Beef Burgundy		8.00	7.64	12.82	10.00
Beef Sirloin		8.27	8.27	18.18	15.09
Ham		7.54	7.63	13.64	13.48
Omelet		7.09	7.44	15.36	15.58
Omelet		7.27	7.45	16.09	15.91
Smokey link Sausage		7.64	7.82	13.00	16.36
Salisbury Steak		7.82	7.45	14.54	12.18
Roast Turkey		7.82	7.64	15.09	13.54
Swiss Steak		7.54	6.36	12.91	7.09
French Fried Shrimp		8.36	7.82	17.18	14.91
	Mean	7.74	7.55	14.88	13.41
Starches					
Noodles		7.36	7.54	12.09	11.18
Mashed Potatoes		7.09	7.27	11.27	11.45
Potato logs		7.27	7.54	12.18	13.54
Whipped Potatoes		7.27	7.00	11.82	12.64
Sweet Potatoes		6.54	6.45	10.18	8.36
Whipped Potatoes		7.00	7.00	12.64	10.73
Rice		7.18	6.82	14.82	11.91
	Mean	7.10	7.09	12.14	11.40
Vegetables					
String Beans		6.73	6.36	12.00	9.73
String Beans		6.91	6.09	11.82	7.64
Peas - Carrots		6.45	6.18	8.73	8.82
Peas w/Pimientoes		5.91	6.18	8.82	7.64
Peas		6.45	6.27	9.91	10.27
Mixed Vegetables		6.91	6.36	12.18	11.27
	Mean	6.56	6.24	10.58	9.23
Dessert					
Apple Slices		7.27	8.01	16.73	19.59
	Grand Mean	7.24	7.11	13.08	12.04

†Before = SPS 8, After = SPS 10 or 11.

Besides examining SPS results, we may also study GPS surveys taken before and after the six weeks of *ad libitum* exposure to ration foods. Mean results for hedonic and frequency ratings for GPS 1 and 17 as shown in Tables 6 and 7. Analyses of variance appear in Appendix G–2.

The analyses of variance show no overall difference between surveys for hedonic ratings or for frequency desired of ration items; there is no change at all in the average hedonic rating of 7.0. Nonration foods, however, increase significantly in both hedonic and frequency desired, reflecting a greater desire for what has been inaccessible.

With ration foods, an interaction is evident between tests and foods, that is to say, there is some inconsistency in the way food ratings shift. In point of fact, all the foods increase very slightly in hedonic rating except for one that declines precipitously by two hedonic units (Table 7). That one item is Swiss steak, and complaints heard throughout the study suggest that this specific food was of very low quality. Quite evidently the low quality of that item is reflected in the supposedly abstract General Preference Survey.

It is possible to do further research with the present data to see if there is a corresponding general decline in the subjects' mood ratings (their psychological state), taken several times a day, and their hedonic acceptability ratings for foods actually consumed, which they recorded in their daily food log at all times of consumption.

In the prior published literature there are just a few references to the effect of continued exposure to certain foods on the preference ratings for those foods. Siegel and Pilgrim (1958) tried two alternating military canned food menus over a 22-day period with 79 college men.[132] They discerned some decline in both preference and consumption under the repetitive diet but suggested that initially high-rated foods generally decline less than low-rated items. This latter conclusion is borne out by our own data only by the fact that the two main entrees that dropped by more than one hedonic unit during the fortnight of Stages II or III were indeed items that were rated somewhat below average. (These were canned Beef with sauce and frozen Swiss steak). In another early study, Schutz and Pilgrim (1958) arrived at comparable conclusions using 41 canned food items over 37 days.[127]

Kamen and Peryam (1961) tested the acceptability of repetitive diets with 72 enlisted men over 24 days,[77] using a six-day preplanned menu, a three-day preplanned menu, and three-day cycle planned by the men themselves when they were assigned at random to sub-groups of six people. They measured preference with the standard hedonic scale and consumption by the percentage of the serving that was consumed (0, 33%, 67%, 100%). They found no general decline or increase in consumption or preference over time. However, they report a problem of absentees: "Thus, the 'self-selection', being absent or not rated, might mask downward trends in preference and consumption over time". Siegel and Pilgrim (1958) also document evidence of this bias in their own experiment.[132]

Table 6. Mean GPS Preference Ratings for Ration and Nonration Foods Before and After Six Weeks of Ration Experience. (Stages II-IV, N = 9)†

	Ration		Nonration		
	Before	After	Before		After
Hedonic	7.0	7.0	6.9	**	7.2
Frequency	8.3	10.0	9.1	**	10.6

†Before = GPS 1
After = GPS 17

**$p < 0.01$

Table 7 . Ration foods exhibiting differences in mean preference ratings between GPS 1 and 17 (df = 8).

Food Item No.	Name	1st rating	2nd rating	Difference (17-1)	P-value
Hedonic Ratings:					
31	sausage links	6.89	7.78	+0.89	0.035*
52	buttered noodles	6.67	7.44	+0.77	0.088
54	swiss steak	7.67	5.67	-2.00	0.039*
80	pears, canned	7.44	7.89	+0.45	0.035*
177	peaches, canned	7.22	8.11	+0.89	0.020*
367	apricots, canned	6.78	7.56	+0.78	0.065
Frequency Ratings:					
51	steamed rice	6.56	11.56	+5.00	0.008**
52	buttered noodles	7.67	14.67	+7.00	0.008**
177	peaches, canned	6.78	14.78	+8.00	0.005**
367	apricots, canned	5.56	11.00	+5.44	0.040*
54	swiss steak	9.44	6.22	-3.22	n.s.
31	sausage links	8.44	14.33	+5.89	n.s.
80	pears	9.11	14.00	+4.89	n.s.

* $p < 0.05$
** $p < 0.01$
ns = $p > 0.10$

For just a few specific military foods, it is possible to compare Kamen and Peryam's hedonic results with our SPS results despite the differing experimental conditions. We also recognize that though the specific canned rations bear the same label-name, the actual quality of the foods may have changed over the fifteen years since the earlier study. We have comparable data for ten canned foods (Table 8). In both experiments, virtually all of these declined moderately in preference. The only increase in hedonic rating evidenced in both experiments was Ham and Eggs. Subjects seem to like it slighly more over time but want less of it. Kamen and Peryam (1961) show a declining rate of consumption of it over time,[77] and our own frequency-desired measure also shows a decline. The only single food showing a different trend in the two experiments is canned Tuna, in our own data reflecting the general decline but in the earlier experiment showing a slight rise in preference. The percentage consumed declines, however, as does our measure of frequency desired. Our own conclusions thus seem to be reasonably well supported by the earlier experimental data, though Kamen and Peryam did not reach the conclusion that there was a general decline in ratings. As in our experiment, an overall test of significance did not prove the generalized decline, but close inspection of the data reveals it clearly as a consistent pattern. Analyses of variance for our experiment (shown in Appendix G—1) reveal significant shifts of the food ratings, but no test-to-test effects.

How does restricted mealtiming affect stated preference for food items? The effect of restricted mealtiming on preference ratings can be assessed by examining results of the questionnaires at the end of the Stage IV *ad libitum* period and comparing the results at the end of Stage V three weeks later, and results after another three weeks at the end of Stage VI, when the experiment was terminated. It may be remembered from the Method section of this report that in a split sample, some subjects were restricted to a big breakfast in Stage V, then a big dinner in Stage VI. Other subjects had the restrictions in reverse order and a few subjects were continued on an unrestricted *ad libitum* regime throughout both of the last stages. Not all of the subjects, however, completed all of the questionnaires and our analysis here is generally limited to eleven subjects who were on restricted mealtimes.

It is possible to examine the effects of mealtime restrictions on ratings of all ration foods on the SPS instruments. Some of these ration foods, especially some of the frozen foods and canned fruits also appear on the GPS form, which provides a separate check. And perhaps equally important, the GPS ratings for nonration food items may be affected indirectly and may also be studied.

The ration foods show a general decline in SPS ratings, on both the hedonic and frequency scales, through the first restricted period. The drop is clearly reflected in the overall averages for both frozen and canned foods (Table 9). The frozen food averages remain low through the second three weeks of restriction but the canned food averages recover exactly to their earlier levels, prior to the restrictions. Apparently, in this context, canned foods are ultimately less tiring than frozen foods over a prolonged period of time.

Table 8. Change in Hedonic Ratings for Canned Foods after Continued Exposure. Comparison of Results from Stage IV with Kamen & Peryam's (1961; a, b, c, are three different experimental groups).

	Change in Hedonic Rating	
	Kamen & Peryam	Present Study
Beef steak	a. -0.3 b. +0.2 c. -0.1	-0.46
Spaghetti with beef	a. -0.4 b. -0.3 c. -0.1	-0.55
Turkey	a. -0.1 b. +0.1 c. -0.2	-0.82
Tuna	c. +0.2	-0.37
Ham & eggs	c. +0.5	+0.15
Apricots	b. -0.2 c. -0.1	-0.45
Fruit cocktail	b. -0.3 c. -0.1	-0.72
Peaches	a. 0.0 b. -0.1 c. -0.1	-0.27
Peas	c. -0.1	-0.09
Pineapple	a. 0.0 b. 0.0 c. 0.2	
Mean change	–0.08	–0.40

Table 9. Mean SPS Preference Ratings for Ration Foods Before and After Three and Six Weeks of Mealtime Restriction (Stages V-VI, N = 11)

		Before[a]	3 Weeks[b]	6 Weeks[c]
MCI	Hedonic	6.5	6.1	6.5
	Frequency	8.5	8.3	8.5
FROZ	Hedonic	6.4	6.3	6.2
	Frequency	9.0	8.4	8.4

[a] Before = MCI SPS 15, FROZ SPS 16

[b] 3 Weeks = MCI SPS 18, FROZ SPS 19

[c] 6 Weeks = MCI SPS 20, FROZ SPS 21

Because subjects had access to both canned and frozen foods throughout Stages IV, V, and VI, it will be interesting in later analysis to see if actual food choice was modified in favor of canned foods throughout the six weeks of limited mealtiming.

Separate analyses of variance over the three SPS tests do not reveal statistically significant differences, probably because the canned ration means recoup their decline by the end of Stage VI and, in the case of frozen foods, the persistent decline is, in fact, quite small (see ANOVA summary, Appendix G–3).

Only one interaction appears significant in the analysis of variance; i.e., tests x foods in the canned food frequency ratings. Where this interaction occurs it is worthwhile to examine the individual items to gain some insight into the role of specific foods under these difficult restrictions. Pineapple increases in desired frequency from 7.3 to an astonishing 17.5 during the first three weeks and then declines again to 8.59 by the end of the experiment. Chocolate fudge disk, originally rated 13.68, declines sharply to 8.91 but rises again to 15.54. These major fluctuations in accessory foods probably reflect their changeable role in alleviating the tedium and duress of main entree selection through six weeks of very difficult and important meal choices when subjects are restricted to only one meal a day (Table 10).

Among canned main entrees, it is interesting to note that chicken or turkey (the two items were offered interchangeably as if they were one item) rose slightly but nonsignificantly in frequency desired from 6.36 to 9.64. Perhaps canned poultry has relatively good durability in preference when compared to other canned meat products.

GPS ratings for ration foods show a slight average decline, as do the SPS ratings. The change is not statistically significant but is evidenced for both hedonics and frequency desired. Conversely, nonration foods rise slightly though nonsignificantly in hedonic and frequency ratings. Perhaps absence does make the heart grow fonder of foods temporarily inaccessible. (Averages shown in Table 11; ANOVA in Appendix G–4).

Mean ratings for individual nonration foods, both before and after meal restrictions, show the items that conspicuously increased in preference. (Table 12 for hedonic ratings, Table 13 for frequency desired). Items that have changed in the same direction for hedonic and frequency ratings are indicated by underlining in both Tables 12 and 13, though the changes are not necessarily considered statistically significant. Items are tabled if their changes show significance at the ten percent level and all other items are omitted. For hedonic ratings, all but seven of the sixty items show a positive shift, and the negative shifts are slight indeed, only one of them significant at the five percent level.

Noticeable among the types of nonration foods that shifted positively during mealtime restrictions are very few main entrees (fried chicken, pizza, for example). Lettuce salad and a few vegetables appear but the bulk of the favored items are dessert pies and accessory or specialty foods: banana cream pie, cheesecake, chocolate cookies, doughnuts, submarine

Table 10. Effects of Mealtime Restriction on MCI Preference Ratings for Frequency Desired (df = 10).

MCI SPS FREQUENCY RATING

SPS Surveys	Food Item	1st Rating	2nd Rating	Difference (2nd-1st)	P-value
15,18:	During Stage V				
	pineapple	7.30	17.50	10.20	0.066
	chocolate fudge disk	13.68	8.91	-4.77	0.079
18,20:	During Stage VI				
	chicken or turkey	6.27	9.64	3.37	0.099
	pineapple	17.50	8.59	-8.91	0.070
	chocolate fudge disk	8.91	15.54	6.63	0.050
15,20:	During Stages V & VI				
	chocolate nut roll	12.00	17.82	5.82	0.085
	chicken or turkey	6.36	9.64	3.28	0.089
	ham and eggs	5.73	3.18	-2.55	0.090
	beef with sauce	4.73	2.82	-1.91	0.013*
	sweet chocolate disk	15.82	19.73	3.91	0.051

*$p < 0.05$

Table 11. Mean GPS Preference Ratings for Ration and Nonration Foods Before and After Six Weeks of Mealtime Restriction. (Stages V and VI, N = 11)†

	Ration		Non-ration	
	Before	After	Before	After
Hedonic	6.9	6.8	6.9	7.2
Frequency	9.3	9.1	9.5	10.4

†Before = GPS 17
After = GPS 22

Table 12. Nonration foods exhibiting differences in mean hedonic ratings between GPS 17 and 22 (df=10)

No.	Food Items Name	1st Rating	2nd Rating	Difference (22-17)	P-value
3	tea	8.09	7.64	-0.45	0.096
10	grape juice	7.82	7.18	-0.64	0.067
12	turnip greens	4.24	5.69	1.45	0.007**
16	hot turkey sandwich	8.27	7.64	-0.63	0.088
40	Italian dressing	7.35	8.09	0.74	0.020*
43	French toast	7.27	8.09	0.82	0.019*
44	pizza	8.09	8.54	0.45	0.053
47	split pea soup	5.00	5.97	0.97	0.006**
50	simmered sauerkraut	5.73	6.36	0.63	0.045*
77	angel food cake	6.27	6.73	0.46	0.095
83	peach shortcake	6.86	7.53	0.67	0.092
85	Polish sausage	7.09	7.64	0.55	0.051
88	fried chicken	7.82	8.36	0.54	0.025*
101	vegetable juice	5.28	5.82	0.54	0.055
102	peaches (fresh)	7.91	8.45	0.54	0.051
103	thousand island dressing	6.82	7.18	0.36	0.037*
109	hashed brown potatoes	7.45	7.91	0.46	0.016*
110	cabbage	5.82	7.05	1.23	0.043*
111	sweet rolls	7.54	8.09	0.55	0.051
115	chefs salad	7.73	8.18	0.45	0.016*
116	bean soup	5.73	7.31	1.58	0.016*
117	banana cream pie	7.09	8.00	0.91	0.024*
120	pineapple sundae	5.85	6.82	0.97	0.028*
121	lettuce salad	8.09	8.36	0.27	0.081
122	buttered carrots	6.52	7.00	0.48	0.033*
147	chocolate cookies	7.36	8.26	0.90	0.008**
164	grapefruit half (fresh)	6.73	7.45	0.72	0.011*
168	vegetable soup	6.27	6.73	0.46	0.095
170	tacos	7.36	8.18	0.82	0.001**
179	submarine sandwich	7.54	8.09	0.55	0.051
189	macaroni salad	7.27	7.73	0.46	0.053
200	lemon meringue pie	7.00	7.73	0.73	0.011*
204	French fried onion rings	8.00	8.45	0.45	0.095
206	chocolate drop cookies	7.51	8.09	0.58	0.046*
220	sloppy joes	7.18	8.00	0.82	0.019*

*p < 0.05
**p < 0.01

Table 12 continued

No.	Food Items Name	1st Rating	2nd Rating	Difference (22-17)	P-value
221	cheesecake	7.35	8.11	0.76	0.027*
223	plums (fresh)	6.73	7.09	0.36	0.037*
235	salami sandwich	6.36	7.27	0.91	0.004**
241	milk	6.64	6.91	0.27	0.081
243	spice cake	6.73	7.36	0.63	0.045*
245	potato chips	6.64	7.54	0.90	0.042*
250	pizza	8.09	8.64	0.55	0.025*
255	lemon chiffon pie	6.64	7.82	1.18	0.023*
260	French dressing	7.73	8.27	0.54	0.025*
272	grapefruit juice	6.18	6.73	0.55	0.025*
277	cherry upside down cake	6.86	7.63	0.77	0.027*
286	waffles	6.82	7.45	0.63	0.088
295	roast veal	6.03	6.48	0.45	0.093
306	bologna sandwich	6.82	7.36	0.54	0.081
309	coconut cream pudding	5.93	8.27	2.34	0.051
315	buttered whole kernel corn	7.82	7.45	-0.37	0.016*
321	cold cereal	6.54	7.82	1.28	0.033*
330	baked tuna + noodles	6.82	7.38	0.56	0.025*
336	soft serve ice cream	6.54	7.91	1.37	0.030*
343	watermelon	7.45	7.18	-0.27	0.016*
348	grilled steak	7.73	7.36	-0.37	0.025*
360	bacon, lettuce + tomato sandwich	7.00	7.64	0.64	0.045*
364	doughnuts	7.82	8.36	0.54	0.051
377	griddle cakes	6.91	7.64	0.73	0.053
378	instant coffee	5.88	4.91	-0.97	0.054

*$p < 0.05$
**$p < 0.01$

Underlined items changed noticeably, if not significantly, in both hedonic and frequency ratings during mealtime restriction.

Table 13. Nonration foods exhibiting differences in mean frequency ratings between GPS 17 and 22 (df=10)

No.	Food Item Name	1st Rating	2nd Rating	Difference (22-17)	P-value
3	tea	20.82	15.08	-5.74	0.046*
8	strawberry shortcake	9.54	14.03	4.49	0.044*
12	turnip greens	3.44	5.36	1.92	0.049*
43	French toast	13.27	16.61	3.34	0.038*
62	hamburger	14.00	17.00	3.00	0.059
84	stuffed green peppers	6.27	5.00	-1.27	0.040*
88	fried chicken	10.00	14.45	4.45	0.014*
99	butterscotch sundae	4.52	8.09	3.57	0.077
117	banana cream pie	6.00	12.09	6.09	0.028*
121	lettuce salad	19.09	23.27	4.18	0.033*
122	buttered carrots	6.28	9.45	3.17	0.083
132	strawberry chiffon pie	5.87	9.45	3.58	0 0.043*
138	bananas	10.36	13.00	2.64	0.083
139	milkshake	13.18	17.09	3.91	0.098
140	canned green beans	6.54	4.82	-1.72	0.085
147	chocolate cookies	11.54	16.64	5.10	0.048*
154	banana cream pudding	7.36	13.64	6.28	0.018*
173	grilled lamb chops	4.47	8.24	3.77	0.031*
174	white cake	5.00	9.27	4.27	0.054
178	boiled navy beans	8.21	5.89	-2.32	0.033*
179	submarine sandwich	8.45	10.45	2.00	0.036*
185	strawberry gelatin	9.91	7.09	-2.82	0.084
194	pepper steak	10.37	7.24	-3.13	0.087
196	plain muffins	8.45	12.82	4.37	0.093
201	Boston cream pie	8.64	13.08	4.44	0.059
204	French fried onion rings	11.82	15.64	3.82	0.093
206	chocolate drop cookies	12.31	17.09	4.78	0.078
209	ginger ale	10.73	8.18	-2.55	0.053
214	marble cake	6.54	9.73	3.19	0.020*
219	cold potato salad	7.36	9.82	2.46	0.055
220	sloppy joes	9.27	12.54	3.27	0.089
221	cheesecake	7.96	12.76	4.80	0.024*
224	hot oatmeal	4.64	8.64	4.00	0.055
250	pizza	12.18	16.82	4.64	0.021*
277	cherry upside down cake	7.76	11.93	4.17	0.001**
279	cherry soda	7.64	4.44	-3.20	0.054
302	egg salad sandwich	8.00	11.27	3.27	0.075
308	vinegar + oil dressing	12.00	15.18	3.18	0.052

*$p < 0.05$
**$p < 0.01$

Table 13 continued

No.	Food Item Name	1st Rating	2nd Rating	Difference (22-17)	P-value
321	cold cereal	9.36	16.91	7.55	0.017
330	baked tuna + noodles	6.91	9.45	2.54	0.082
345	frankfurter, cheese + bacon	9.27	12.09	2.82	0.099
348	grilled steak	13.54	10.27	-3.27	0.038*
364	doughnuts	13.64	17.91	4.27	0.099
370	strawberry sundae	9.00	13.18	4.18	0.062
377	griddle cakes	8.36	11.09	2.73	0.011*
378	instant coffee	11.26	6.64	-4.62	0.073

*$p < 0.05$
**$p < 0.01$

Underlined items changed noticeably, if not significantly, in both hedonic and frequency ratings during mealtime restriction.

sandwich, sloppy joe, French toast, griddle cakes. They seem to suggest an increased desire for variety and novelty, not so much in the basic main entrees, but in the incidental foods that can make a menu more interesting. It is also possible that the subjects experienced a heightened desire for "sweets" as a result of concentrating all their daily caloric intake at one time of the day and having lower blood sugar levels the rest of the day.

How well does stated preference for main entrees predict individual food-choice behavior? This question may be approached in several ways according to how we define and measure "food-choice behavior". Here we are taking as a base the total number of entrees a subject selects during a stage of the experiment. For each person then, a score is computed for each main entree, from the number of times he selects that item, as a percentage of the total number of food items (i.e., entrees) selected. The choice score is thus the relative number of times that a specific entree was selected by that person.

Now, we may see how well a person's most recent SPS preference ratings for a main entree predict the relative frequency of his choosing it during the subsequent stage of the experiment. This is done by a separate regression for each person, for each Stage II through VI (Table 14). First, simple regressions indicate the predictive value of the most recent hedonic measure and frequency measure separately; then a multiple regression indicates their joint predictive value.

During the first four weeks, the unrestricted mealtime periods of Stages II and III, there are seven out of 17 subjects with significant correlations of preference measures and choice behavior (Table 14). But for as many as five of the subjects, the significance is achieved only for the choice-array of canned foods, not for frozen foods. There is no ready explanation for this difference between canned and frozen foods.

There is a great deal of difference in the predictability of preference ratings among the subjects. For some subjects, as with No. 4 during Stage II on frozen foods, the correlations are quite minimal or even random, less than 0.1 in this case. Another subject achieves correlations of 0.7 in this early stage, for canned food. With the poorly predicting subjects, however, there is a noticeable improvement over time, so that average predictability is much higher for Stage VI than for earlier stages. Experience apparently improves predictive ability. By Stage VI, four subjects out of 21 (58, 59, 66, 70) achieve an r of 0.9 or better. Virtually all subjects finally achieve an r over 0.5. The median r for all subjects during Stage VI is 0.68, and the values range from 0.48 to 0.97.

One may also look at how much of the variability in choice-behavior is explained by the preference data. Considering predictability across subjects, there are more degrees of freedom for detecting significance but the percentages are quite low due to combining poorly predictive subjects with the more effectively predicting subjects (Table 15). Here

Table 14. Correlations of Preceding Preference Ratings with Relative Choice Frequency Among Main Entrees for Each Stage of the Experiment by Individual Subjects (n = 21)

Subject No.	STAGES II & III CANNED			FROZEN			STAGE IV			STAGE V FROZEN & CANNED			STAGE VI		
	H	F	H&F	H	F	H&F	H	F	H&F	H	F	H&F	H	F	H&F
1	--	--	—	—	—	—	.58	.60	.61	.53	.48	.53	.52	.64	.64
2	.56	.57	.63	.29	.18	.30	.72	.70	.74	.75	.54	.76	.62	.72	.73
3	.74	.79	.79	.55	.45	.57	.64	.67	.67	.52	.46	.52	.45	.68	.76
4	.11	.21	.52	.09	.10	.10	.58	.57	.59	.50	.46	.50	.27	.72	.75
5	.41	.46	.47	.12	.12	—	.58	.43	.58	.70	.54	.71	.78	.82	.65
6	.56	.45	.57	.23	.21	.71	.12	.02	.20	.11	.30	.41	.43	.48	.49
51	.30	.26	.38	-.11	.13	.61	.02	.07	.14	.53	.65	.65	.72	.71	.73
53	.41	.09	.60	.55	.26	.65	.21	.37	.39	.46	.39	.46	.44	.44	.48
54	.78	.84	.84	-.10	.22	.70	.50	.45	.51	.49	.70	.71	.46	.57	.57
55	.29	.36	.36	.68	.69	.73	.26	.29	.33						
56	.18	.42	.65	.30	.31	.32	.19	.44	.58	.77	.68	.77	.64	.57	.64
57	.67	.89	.95	.51	.45	.56	.76	.89	.89						
58	.69	.76	.76	.72	.38	.78	.41	.49	.50	.64	.71	.73	.55	.88	.89
59	.70	.49	.74	.18	.50	.66	.66	.63	.68	.72	.98	.98	.78	.92	.93
61	.42	.40	.53	.55	.64	.65	.36	.28	.38	.33	.30	.36	.57	.48	.51
62	.77	.82	.82		.39		.34	.44	.45	.51	.68	.69	.49	.77	.80
63	.17	.11	.19	.45	.74	.75	.20	.18	.53	.32	.38	.38			
64				.28	.30	.31	.22	.04	.34	.47	.72	.76	.61	.66	.66
66										.68	.84	.85	.61	.94	.95
68							.52	.69	.73	.49	.47	.50	.50	.56	.57
69							.11	.52	.64	.58	.72	.72	.30	.51	.54
70							.34	.31	.35	.50	.63	.63	.74	.96	.97
70										.70	.77	.80	.62	.82	.82
72										.42	.35	.43	.42	.66	.68

------ $p < .05$
______ $p < .01$

Table 15. Percentage of Variability of Relative Food Choice Explained by Prior Preference Ratings Across Subjects*

Predictor Rating	Stage: Ad Libitum II	Ad Libitum III	Ad Libitum IV	Restricted V	Restricted VI
Hedonic	16% (15)	29% (17)	21% (21)	31% (22)	32% (21)
Frequency	19% (16)	30% (17)	25% (21)	39% (22)	53% (21)
Hedonic + Frequency	33% (15)	46% (16)	31% (21)	44% (22)	54% (21)

*Group means based on arc sin transformations of individual percentages; N in parentheses.

we see clearly the understandable superiority of the frequency-desired measure over the hedonic measure in predicting relative choice-frequency. Of course, this is to be expected and one would be hard-put for an explanation if it were not so. During Stage VI, the preference frequency rating explains 53 percent of the relative choice-frequency of the main entrees. The hedonic measure adds little or nothing at this stage. Much earlier, in Stages II and III, when there are no mealtime restrictions, the hedonic ratings do contribute substantially to explaining the variance in choice behavior.

Table 16 reorganizes the group results for Stages II and III into those for canned rations and those for frozen rations. Predictability appears to be greater for relative consumption of the canned foods than for the frozen ones; however the overall effect is not statistically significant ($F = 1.59$, $df = 1,14$) and is due to large individual differences.

Percentage of variability explained is also computed for each subject individually (Tables 17 and 18). Once again, the person-to-person variability is demonstrated, some subjects predicting quite poorly. With more experience, by the last stage of the experiment, the poor predictors have improved. When classified by food type (Table 19), the percentages show that maximum predictability for a given subject has an equal chance of being for frozen or canned food – thus confirming the lack of any true effect of ration type on predictability as discussed for Table 16.

The effect of mealtime restriction on the relationship between stated preference and relative food choice is best seen in Table 20. Unlike Table 15, here the control subjects have been separated from those under the Breakfast-only or Dinner-only regimen. Note that most of the overall improvement in predictability of choice is due to the restricted subjects with little or no difference in predictability as a result of which type of single daily meal they are eating. These results suggest that restricting the time of eating produces a greater awareness of food (see Appendix H) which in turn enables one to be more conscious of what he or she would choose to eat in the upcoming three weeks.

Would measures of relative preference among main entrees be more useful than the traditional absolute measures of preference? The now traditional hedonic and frequency-desired scales are "absolute" in the sense that each food item in the General Preference Survey is supposed to be rated independently of any menu or any choice-array of alternative menus.

Also on the Special Preference Survey rating forms, conceptually and in reality, a subject could give extreme ratings to all the food items or meat packs, and could state that each is desired with extremely high or extremely low frequency. As with the GPS, the subject does not directly compare the relative degree of liking. Nor is the subject constrained to any minimum or maximum of total food servings within a month. In point of fact, virtually all respondents report desired frequencies of servings whose total would be far too great to be consumed.

Table 16. Percentage of Variability of Canned vs. Frozen Relative Food Choice During <u>Ad Lib</u> Stages Explained by Prior Preference Ratings Across Subjects†

Stage II & III

CANNED			FROZEN		
H	F	HF	H	F	HF
29% (16)	32% (16)	43% (16)	17% (16)	17% (17)	36% (15)

†Group means based on arc sin transformations of individual percentages; N in parenthesis.

Table 17. Percentage of Variability in Relative Food Choice During *Ad Lib* Stages Explained by Prior Preference Ratings.

	STAGE								
	II			III			IV		
Predictor rating	Hedonic	Fre-quency	Hedonic & Frequency	Hedonic	Fre-quency	Hedonic & Frequency	Hedonic	Fre-quency	Hedonic & Frequency
Subject									
1	-	-	-	-	-	-	34%	36%	37%
2	32%	32%	40%	9%	3%	9%	52%	49%	55%
3	30%	20%	32%	56%	62%	62%	41%	45%	45%
4	1%	1%	1%	1%	4%	27%	33%	33%	34%
5	16%	21%	22%	1%	1%	-	34%	19%	34%
6	31%	20%	33%	5%	4%	50%	2%	0%	4%
51	1%	2%	37%	9%	7%	14%	0%	0%	2%
53	16%	1%	36%	30%	7%	42%	5%	14%	15%
54	1%	5%	49%	61%	70%	71%	25%	20%	26%
55	8%	13%	13%	47%	48%	53%	7%	9%	11%
56	3%	18%	43%	9%	10%	10%	3%	20%	33%
57	26%	20%	31%	44%	79%	90%	57%	80%	80%
58	47%	57%	58%	52%	14%	60%	17%	24%	25%
59	3%	25%	44%	48%	24%	55%	43%	39%	46%
61	30%	41%	42%	17%	16%	28%	13%	8%	14%
62	-	15%	-	59%	67%	67%	12%	20%	20%
63	3%	1%	4%	20%	55%	56%	4%	3%	28%
64	-	-	-	8%	9%	10%	5%	0%	12%
66	-	-	-	-	-	-	-	-	-
68	-	-	-	-	-	-	27%	47%	53%
69	-	-	-	-	-	-	1%	27%	41%
70	-	-	-	-	-	-	12%	10%	12%

Table 18. Percentage of Variability in Relative Food Choice During Restricted Mealtiming Stages Explained by Prior Preference Ratings.[a]

Predictor Rating		Stage V Hedonic	Stage V Fre-quency	Stage V Hedonic & Frequency		Stage VI Hedonic	Stage VI Fre-quency	Stage VI Hedonic & Frequency
Subject								
1	D	28%	23%	28%	B	27%	41%	41%
2	B	56%	30%	58%	D	38%	53%	53%
3	A	27%	21%	27%	A	21%	47%	57%
4	D	25%	21%	25%	B	8%	52%	56%
5	B	49%	29%	50%	D	61%	67%	43%
6	A	1%	9%	16%	A	18%	23%	24%
51	B	28%	42%	42%	D	52%	51%	53%
53	D	21%	15%	21%	B	19%	20%	23%
54	B	24%	49%	51%	D	21%	33%	33%
56	A	60%	46%	60%	A	41%	32%	42%
58	B	41%	51%	53%	D	30%	77%	80%
59	B	52%	97%	97%	D	60%	85%	87%
61	D	11%	9%	13%	B	33%	23%	36%
62	D	26%	46%	48%	B	24%	60%	63%
63[b]	A	11%	14%	14%	A			
64	B	22%	52%	58%	D	38%	43%	44%
66	B	46%	71%	72%	D	37%	89%	90%
68	D	24%	22%	25%	B	25%	32%	32%
69	D	34%	52%	52%	B	9%	26%	30%
70	A	25%	40%	40%	A	55%	92%	93%
70[c]	D	50%	59%	64%	B	38%	67%	67%
71	B	18%	12%	19%	D	18%	43%	46%

[a]Letters A, B, and D indicate Ad libitum, Breakfast-only, and Dinner-only conditions respectively; subject 57 not included due to emotional difficulties and unreliability of data.

[b]Subject's data for stage VI not included because he consumed unusually large amounts of bread instead of rations.

[c]After completing ad libitum conditions, subject repeated Stages V and VI as D and B respectively.

Table 19. Percentage of Variability of Relative Canned or Frozen Food Choice During *Ad Lib* Stages Explained by Prior Preference Ratings.

	STAGES II & III						STAGE IV		
	CANNED			FROZEN			CANNED & FROZEN		
Predictor rating	Hedonic	Frequency	Hedonic & Frequency	Hedonic	Frequency	Hedonic & Frequency	Hedonic	Frequency	Hedonic & Frequency
SUBJECT									
1	–	–	–	–	–	–	34%	36%	37%
2	32%	32%	40%	9%	3%	9%	52%	49%	55%
3	56%	62%	62%	30%	20%	32%	41%	45%	45%
4	1%	4%	27%	1%	1%	1%	33%	33%	34%
5	16%	21%	22%	1%	1%	–	34%	19%	34%
6	31%	20%	33%	5%	4%	50%	2%	0%	4%
51	9%	7%	14%	1%	2%	37%	0%	0%	2%
53	16%	1%	36%	30%	7%	42%	5%	14%	15%
54	61%	70%	71%	1%	5%	49%	25%	20%	26%
55	8%	13%	13%	47%	48%	53%	7%	9%	11%
56	3%	18%	43%	9%	10%	10%	3%	20%	33%
57	44%	79%	90%	26%	20%	31%	57%	80%	80%
58	47%	57%	58%	52%	14%	60%	17%	24%	25%
59	48%	24%	55%	3%	25%	44%	43%	39%	46%
61	17%	16%	28%	30%	41%	42%	13%	8%	14%
62	59%	67%	67%	–	15%	–	12%	20%	20%
63	3%	1%	4%	20%	55%	56%	4%	3%	28%
64	–	–	–	8%	9%	10%	5%	0%	12%
66	–	–	–	–	–	–	–	–	–
68	–	–	–	–	–	–	27%	47%	53%
69	–	–	–	–	–	–	1%	27%	41%
70	–	–	–	–	–	–	12%	10%	12%

Table 20. Percentage of Variability of Relative Food Choice During Restricted Mealtiming (Stages V & VI) Explained by Prior Preference Ratings Across Subjects†

	Mealtime Condition		
Predictor Rating	Breakfast (n = 17)	Dinner (n = 17)	*Ad Lib* Control (n = 9)
Hedonic	31%	34%	29%
Frequency	46%	48%	38%
Hedonic & Frequency	52%	50%	44%

†Group means based on arc sin transformations of individual percentages.

In our experiment, we are dealing with highly responsible, educated and motivated respondents which is not usually the case with the typical military General Preference Survey of enlisted personnel. But even in this experiment there are strong indications that subjects were reporting desired frequencies of servings that are often unrealistically high.

The reporting of very high total desired frequencies by some of the subjects may considerably distort the overall picture. This may be shown by examining the desired frequencies reported just for main entrees of canned foods, after the subjects have had two weeks experience eating them (that is, after Stage II or III). They know the foods well. Yet four out of eleven Minnesota subjects have total servings of main entrees desired per month of 135 up to 175. In ascending order of total main meals desired per month for the eleven subjects, we compute: 28, 29, 31, 43, 60, 62, 84, 135, 162, 167, 175.

There are, of course, some major individual differences in the number of main entrees actually eaten in a month. But the actual differences are far less than suggested by the stated desired frequency. To attain greater face validity, the absolute frequency measures were transformed to relative measures by subtracting a person's mean frequency rating from his or her frequency rating for each food. Within a class of foods, such as main entrees, this has some logical appeal for comparing one main entree to the others.

Table 21 summarizes the effect on rank-order preference for eleven canned main entrees when we compute absolute and relative hedonic ratings, as well as absolute and relative frequency-desired ratings. This is based on a single SPS test with only eleven subjects. What we find, in fact, is that the relative measures do not show any substantial difference at all in the rank order of preference for each of the twelve foods. Until the question can be studied more completely, this gives us some reassurance that the traditional, absolute measures are discriminating among food items in the same way that relative measures would. Standard scores (i.e., $[X_i - X]/s.d)$ could have been used to obtain even more valid relative preference measures; but, in this case, would only serve to maintain or decrease the already very slight disparity between the rank orders of preference based on the absolute and relative measures.

In a separate, as yet unpublished study, CPT James Siebold of the Natick Research and Development Command is assaying a slightly different approach than the one we have demonstrated above.[130] The subject is faced with a choice-array of foods, as in our case. But to determine the relative rating for each item, each person's absolute rating is subtracted by the mean of his ratings for the other foods of the choice array, excluding the item in question. This concept then, is similar though not identical to our own.

Quite another approach to this basic question could be made by comparing the results of the final SPS tests (tests 20 and 21), and the results of the second paired-comparisons test, given at the end of the experiment, after Stage VI. Separately for frozen foods and for canned rations, subjects were asked to compare all possible pairs of meal packs,

Table 21. Comparison of Rank-Order Preferences for Canned Main Entrees After Smorgasbord Using Absolute and Relative Ratings (N=11).†

	RANK ORDER OF PREFERENCE				MEAN PREFERENCE RATING			
	Hedonic		Frequency		Hedonic		Frequency	
Entree	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
Turkey Loaf	1	1	3	3	7.91	0.98	11.36	2.02
Tuna	2.5	2	1	1	7.73	0.80	13.82	4.47
Chicken w/ Turkey	2.5	3	2	2	7.73	0.76	12.91	3.56
Spaghetti w/ Meat Sauce	4	4	4	4	7.45	0.52	11.27	1.93
Beans w/ Franks	6	5	11	11	6.82	0.42	6.91	-2.44
Beefsteak	6	6.5	7	8	6.82	-0.11	8.45	-0.89
Beef w/ Sauce	6	6.5	5	6	6.82	-0.11	9.82	+0.47
Beef Slices	8	8	8	9	6.64	-0.31	8.36	-0.98
Beans w/ Meat Balls	9.5	11	9	5	6.55	-0.58	8.18	-0.14
Pork Slices	11	10	10	10	6.45	-0.48	7.18	-2.17
Ham & Eggs	12	12	12	12	5.55	-1.39	6.09	-3.26

†Subjects analyzed: 51, 53, 54, 55, 56, 57, 58, 59, 61, 62, 63

in terms of their own preference. The resultant rank-order preferences for the meal packs could be compared to the results of the SPS hedonic ratings given by the same subjects at the same stage of the experiment.

Lastly, there is quite a different approach that would require new experimental data. One might compare hedonic and desired-frequency measures with the results of a constant-sum scale. With the constant-sum scale, the subject might be presented with a choice-array and be asked to allocate 100 points among the component items, according to his relative preference. This allows one to derive a ratio-scale rather than only a category scale such as the hedonic rating which we treat arithmetically as if it were an interval scale. Certain aspects of the constant-sum scale have been studied by Eric Marder (for General Foods) and by Ronald Gatty (for Proctor & Gamble) but in both cases the reports have not been published.[89,42] The only major study published on a direct comparison of the constant-sum scale and the hedonic scale was by Russell Haley for the Advertising Research Foundation (1970): unfortunately the report had to be written in haste and hardly does justice to the experimental data.[57]

A further opportunity lies ahead with comparisons of the hedonic scale with the magnitude estimation scale for the measurement of preferences. Moskowitz and Sidel (1971) assume this latter scale is equivalent to a ratio scale and have done much to adapt and refine the scale,[98] mainly for purposes of psychophysics and food acceptance research. No detailed experimentation has been done, however, that would allow definitive comparison with the results of hedonic scales on "paper and pencil" food preference surveys.

Conclusions

1. Typically there is a high correlation between the two different measures of food preference (i.e., hedonic rating and desired-frequency rating) indicating that they both measure essentially the same underlying attitude toward food items.

2. Differences in the format and context of this study's two types of food preference surveys (SPS vs. GPS) had no major effect on the average relative preference ratings for common items but did result in generally higher ratings on the shorter Specific Preference Survey. There was no strong evidence to invalidate the use of shortened forms of the standard military food preference survey.

3. Continued sole exposure to the ration items resulted in a moderate decrease in both types of ratings after two weeks and a more substantial decrease after four weeks. This decrease took the form of a general decline in SPS ratings and was not due to large decreases for a few particular items. These results confirm earlier published findings concerning the effects of repetition and boredom on food preferences; however, the observed decreases in stated preference were not reflected when the same ration items were embedded in the General Preference Survey. Instead, boredom with the ration items

was reflected by an increase in the hedonic and desired-frequency ratings for nonration food items.

4. Restricted mealtiming had no substantial *long-term* effect on the preference ratings for ration foods except for inducing large fluctuations in the ratings for accessory foods (e.g., pineapple slices and chocolate). Ratings for nonration foods increased, especially those for desserts and other accessory foods (e.g., pie, cheesecake, cookies, and doughnuts). These results suggest that mealtime restriction increases the desire for variety and novelty in the available menu but not in the form of main entrees. An alternative explanation is that the subjects experienced a heightened desire for "sweets" as a result of concentrating all their daily caloric intake at one time of the day and having lower blood sugar levels the rest of the day.

5. Measures of absolute preference among main entrees did not differ substantially from measures of relative food preference in their ability to discriminate among food items.

6. Predictability of food choice varied greatly among individual subjects but was low overall, with preference ratings never predicting more than 46% of the variability of group choice behavior during the **ad libitum** stages. Predictability improved with increased ration experience and during mealtime restriction. Also, desired-frequency ratings proved to be better than hedonic ratings in predicting relative food choice. The results indicate that these food preference ratings are relatively poor predictors of choice behavior. The present test situation maximized the opportunities for familiarization with both the preference surveys and test foods and, furthermore, limited the number of possible food choices to only eight or twelve entrees over successive two-week spans. Since prediction should be very close to optimal under these conditions, there is reason to question the usefulness of food preference surveys, in their present form, to predict food choice behavior in military dining halls where many more foods are available and where choice can be influenced by a greater variety of uncontrolled variables.

PATTERNS OF NUTRIENT INTAKE AND FOOD CHOICE

Problem

The food-related behavior of individuals can vary along several different, but related, dimensions. A partial list of these would include choice of foods, amount of food eaten, frequency of eating, time of eating, and duration of eating events. Although all of these behavioral measures can be classified under the topic of food habits, nutritionists have traditionally emphasized choice and amount of foods eaten, or adequacy of the diet, in their studies of food habits in humans. Thus, large-scale national and regional dietary surveys have provided cross-sectional data rather than long-term longitudinal data on average daily nutrient consumption for households and individuals. Similar cross-sectional, survey data are also available on military populations. Other dietetic studies have used much smaller samples to study the relationship between patterns of caloric intake and energy expenditure. The food industry has also contributed to the traditional food-habits literature by providing actuarial data from market analyses of the public's consumption of different food types from various food sources.

Although a substantial amount of animal research has been carried out regarding patterns of food intake over time, almost no longitudinal data are available about this important aspect of food habits in presumably healthy, normal humans. The lack of research in this area stems primarily from the difficulty of obtaining detailed accurate measures of the times and amounts of food consumption by individuals over a sufficiently long span of time. Such studies further require a stable choice-array of food items at all times with no limits placed on the amount of food available. The present study is unusual in that it fulfills these experimental conditions. Thus, it is possible from this experiment to determine the consistency of eating and food choice patterns both among and within individuals. Other questions can also be answered regarding the preferred distribution of eating events throughout the day, the relative importance of snacking versus meal-eating, and the relationship between eating patterns and circadian rhythms.

Aside from the importance of such data to nutritionists, there are several reasons why food psychologists might be interested. An understanding of individual food choice behavior is dependent upon a knowledge of the temporally related food habits which partially determine those choices. For instance, it is of only moderate value to know an individual's relative preference for various entrees when over half of his daily food consumption is derived from snack foods. Likewise, one's preferences among cereals may be of little importance in determining food choices in the morning if one usually eats a sandwich at that time. If patterns of food choice are sporadic, then it may not be feasible to base behavioral predictions on relative food preferences and to use such predictions in menu-planning. Furthermore, it is well known that variations in dining hall attendance rates at different mealtimes are often related to differences among individuals' preferred eating schedules. Thus, it is critical from both the nutritional and psychological viewpoints to first understand people's patterns of food choice and consumption before successfully designing or evaluating any food service system.

Review of Literature

Although a substantial amount has been written about human food habits, only a small portion is directly relevant to the patterning of food intake over time, be it over weeks, a day, or a meal. The following review summarizes findings from several types of research which both underscore the importance of the present results and provide a context within which to view them.

Nutritionists' concern about people's eating patterns stems primarily from the results of various national and regional nutrition surveys. For instance, the 1965–66 USDA Household Consumption Survey indicated that the percentage of families having a good diet (i.e., required daily allotment, or RDA, for seven essential nutrients per individual) declined from 60% to 50% since 1955 while the percentage of those having poor diets (i.e., less than 2/3 RDA for more than one nutrient) increased from 15% to 20%. During the same decade, per capita income increased rapidly. Paradoxically, the data suggest that declines in the adequacy of diets were not due to the behavior of low income families. In fact these families (less than $2,000 per year in 1955, $3,000 in 1965) actually decreased the difference between their overall daily nutrient intake and that of the highest income group (>$10,000). Low income families also showed a net increase in their daily intakes of vitamin A and ascorbic acid, while high income families showed a concomitant decrease to the point that one-third were deficient in the RDA for one or more nutrients (Gage, 1973).39 Thus, odd as it may seem, increased affluence in the U.S. does not guarantee better nutrition.

Changes in middle and upperclass eating patterns may provide the key for understanding the etiology of this apparent contradiction. Although any decrement in nutrient intake must eventually depend on the reduced consumption of certain foods, there is often a more fundamental factor. In underdeveloped nations poverty or the unavailability of certain foodstuffs may be the primary factor. In the case of affluent America, available data point to the importance of a shift from the traditional pattern of three square meals per day. Individuals now eat less structured meals at irregular times with a tendency toward snacking and meal skipping. This development is quite recent, as one might expect considering the results of USDA Household Consumption Surveys prior to 1965–66.

The traditional importance of eating three meals per day at fixed times was dramatically demonstrated by Engle-Frisch in her 1943 study of defense plant shift workers during World War II.[29] Workers on the evening shift (1600 to 2400 hours) and those on the night shift (2400 to 0800 hours) kept their food habits relatively unchanged from normal patterns. Thus, when the evening shift workers came home at midnight, they had a late-night snack, slept, and then had breakfast in the morning followed by lunch (dinner) at noon. Similarly, the night shift personnel typically ate breakfast when they got home, then slept, and woke for a family dinner in the late afternoon. Time of day, and not activity, appeared to be the most important determinant of the type of meal eaten.

Today, eating patterns are built around highly variable activity patterns and not vice versa as before. Up to 75% of familes surveyed do not eat breakfast together, and up to 50% have one or more members who regularly skip this meal (LaChance, 1973).[82] Unfortunately, breakfast is not the only meal skipped since it is estimated that 20% of U.S. adults skip lunch and 11% skip dinner (Parrish, 1971).[107] Monello, Seltzer, and Mayer (1965) reported frequent skipping of breakfast to be most prominent among adolescent girls (40% of 145 surveyed) and least prominent among adult women (10% of 165).[95] Lunch was skipped more often by men (46% of 192) and least often by adult women (14% of 165). These data are supported by a recent survey of 589 enlisted personnel at a large Air Force base who stated that they consumed an average of only 16.9 meals per week regardless of food source (Siebold, Symington, Graeber and Maas, 1976).[131] Similar studies conducted at other Air Force bases indicate averages of 15 to 16 meals per week with no more than 25% of the subjects eating the traditional 21, or more, meals per week (Branch and Meiselman, 1973; Branch, Symington, and Meiselman, 1973).[13,14] It is interesting to note that most meals skipped are on weekends, when activity is greater and more variable than on weekdays.

The increased skipping of main meals appears to be compensated by a greater number of daily snacks such that often 20 food contacts are made per day rather than "ideal" 8 or so (LaChance, 1973);[82] however, since snacks provide mainly calories but very little protein or other necessary nutrients (Beyer and Morris, 1974; Parrish, 1971),[7,107] it is unlikely that increased snacking can fully compensate for nutrients lost by meal skipping. Yet the prevalence of snacking is apparently widespread. One recent survey reported that about 90% of the U.S. population regularly eats a limited variety of snack foods (Parrish, 1971),[107] and a similar New York State survey showed that 80% to 90% of all low income familes eat potato chips, donuts, and pastries, and drink soft drinks once or more per month (Seoane, 1971).[128] Between-meal snacking was reported by almost all of the adolescents (N = 397) surveyed by Monello, Seltzer, and Mayer (1965),[95] with boys averaging 3.0 snacks per day and girls averaging 2.3 per day. Fewer adults said they snacked, but those who did (50% of the men and 80% of the women) reported eating an average of 1.4 and 1.5 snacks per day, respectively. As might be expected, the sale of snacks by U.S. retailers climbed from $1.3 billion to $2.2 billion during the period from 1957 to 1966 (Parrish, 1971).[107]

Aside from creating irregular meal patterns, meal skipping and snacking also contribute to the hurried or rushed character of meals both in and outside the home. In 1940, 70% of all foods consumed were prepared at home as opposed to 55% in 1965; but, conversely, only 35% of these foods in 1940 were convenience items as opposed to 45% in 1965. The shift toward convenience foods in the home is also reflected in the per capita consumption of canned or frozen vegetables and fruits which rose 15.5% and 54.6%, respectively, from 1945 to 1968 while fresh vegetables and fruits dropped 76.9% and 42.4% (Parrish, 1971).[107] Although the increase in convenience foods has led to a concomitant increase in the number of food items stocked in grocery stores (from an average of 3500 in 1959 to almost 10,000 in 1974), consumers have effectively reduced their range of purchases by selecting fewer foods rich in Vitamin A and ascorbic acid.

Additional nutritional problems are caused by frozen pastries, ready-to-bake rolls, and premixed cakes in which enriched flour cannot be used because of the resultant decrease in product stability and shelf-life (Parrish, 1971).[107] Thus, even in the home, we may be sacrificing good nutrition for more convenience. The popularity of convenience foods, however, is not surprising in view of their suitability to irregular eating patterns. They can be stored for long periods, packaged as single portions, and prepared quickly and easily.

In addition to more families consuming convenience foods at home, households are more mobile today and eating more often outside the home. While in 1930 only 13% of the food consumed by a given household was eaten away from the home, today over 25% is so consumed, accounting for approximately 40% of the family food dollar (Parrish, 1971).[107] Since the cost of labor and trained personnel has risen rapidly in the last two decades, "fast foods" have become a way of life in the U.S. such that fast-food outlets are now the most rapidly expanding type of restaurant. In 1950 there were only 10 fast-food chains, but by 1969 this number had increased to more than 250. Of the 145,000 restaurants operating in this country in 1971, 30,000 were franchised fast-food outlets serving limited menus (Sherck, 1971).[129]

Although repeated snacking accompanied by meal-skipping can lead to less than the recommended daily intake of certain vital nutrients, it can also have important positive effects on one's health (Fabry and Tepperman, 1970).[32] It is now clearly evident in both man and animals that the distribution of daily caloric consumption over as many as ten periodic small eating events (i.e., nibbling) can lead to lower levels of serum cholesterol and phospholipids than present when the same daily amount of food is consumed in the form of one to three regularly spaced daily meals (Cohn, Joseph, and Allweiss, 1962; Fabry, 1969; Hashim, Arteage, and Van Itallie, 1960; Wadhwa, Young, Schmidt, Elson and Pringle, 1973; Young, Hutter, Scanlan, Rand, Lutwak, and Simko, 1972).[22,30,60,145,152] In addition, such "snacking" increases the body's ability to maintain normal blood sugar levels, but decreases lipogenesis and reduces protein requirements (Cohn et al., 1962; Fabry, 1969; Gwinup, Byron, Roush, Kruger, and Hamwi, 1963; Wadhwa et al., 1973; Young et al., 1972).[22,30,47,145,152] It is intriguing to speculate, as Stare has done (see Trulson et al., 1962),[140] that if people could be taught to snack on the proper foods from a nutritional standpoint without overeating, then they may become much healthier in terms of reduced risk of artherosclerosis, coronary disease, and diabetes mellitus, than if they were to consume the same foods as three "square meals" per day.

The foregoing findings derived from national and regional consumption surveys plus market analyses underscore the nutritional impact resulting from altered temporal eating patterns. Unfortunately, they do not provide detailed information regarding the actual distribution of eating events over time. Although nutritionists have recognized the need for large-scale surveys which can accurately report the frequency and time of eating (see Trulson et al., 1962),[140] they have yet to develop appropriate methods.

Laboratory studies have been somewhat more successful. Caution must be taken, however, to realize the potential artificiality of these studies. Factors such as the types

of foods offered, the uniqueness of the eating environment, the types of subjects, and the restrictions placed on their usual daily activities can all limit the generalizability of the findings. In spite of these limitations, laboratory research on patterns of food consumption deserve some attention. A great deal of research has also been published on animal feeding studies. These results will not be discussed here since most are not directly relevant to our present concerns. The only topic of potential interest is how animals respond behaviorally to compensate for caloric alterations of their diet. The interested reader may wish to consult Balagura (1973),[3] Le Magnen (1971),[85] or Panksepp (1976) for further details.[106]

Understanding caloric compensation has also been the major impetus for most human laboratory feeding studies. In order to readily obtain a variety of caloric dilution factors, investigators have limited their experiments to examining the consumption of liquid diets. The sole use of liquid as opposed to solid food is not surprising since it is also easier to monitor continuously the consumption of liquid diets and to control more precisely their organoleptic qualities. Furthermore, liquids can be more readily presented in a situation in which the subject has no knowledge of the total amount of nutrient available and can vary his intake in an analog rather than discrete fashion (e.g., Hashim and Van Itallie, 1964; Jordan, Wieland, Zebley, Stellar, and Stunkard, 1966).[61,75] In general, the results indicate that lean normal subjects can adjust both the frequency and amount of their intake pattern to maintain a stable body weight when "eating" only liquid diets, even when they are unaware of variations in diet caloric concentration (Campbell, Hashim, and Van Itallie, 1971; Hashim and Van Itallie, 1965).[18,62] However such adjustments do not occur in all individuals, and, when they occur, they usually require two to five days and are not always precise (Spiegel, 1973).[135] Also, people are not able to adjust their intake appropriately in response to caloric variations in the form of preloads or simultaneous gastric loads of liquid diet (Jordan, 1969; Walike, Jordan, and Stellar, 1969).[74,146]

Although such laboratory studies have helped to illuminate the roles of oral and gastric factors in the control of human consummatory behavior, they have provided very little information regarding variations in the pattern of feeding within and across days. Typically they have been short-term studies, none lasting more than 21 days, with most lasting only a day or two. Although Spiegel (1973) cites Hashim and Van Itallie (1965) as having found that normal subjects on liquid diet develop a regular meal pattern of three or four meals per day,[135,62] closer examination reveals that the latter provided unrestricted diet availability to only one subject, a 60-year old man with a deformed mouth. Spiegel herself (1973) reports that,[135] over a total of 21 days, six subjects "ate" an average of 2.2 meals per day of a 1.0 kcal/ml diet and 2.6 meals per day of a diluted 0.5 kcal/ml diet from a laboratory feeding machine. She further reports that six other subjects of similar body weight ate a greater average number of meals per day (3.3 and 3.9, respectively) when the liquid diets were available from both the machine and a take-home supply of premixed jars. Thus, there is some question as to whether the first set of meal frequencies represents true *ad libitum* feeding or whether they are influenced by the requirement that subjects had to "eat" from a feeding machine located in the

laboratory while they lived at home. Spiegel also fails to report any data regarding the timing of meals throughout the day.

Campbell and Becker (1975),[17] also using 1.0 kcal/ml liquid diet, reported that five lean healthy subjects "ate" an average of 4.0 to 8.3 meals per day from a feeding machine over 12 to 25 consecutive days. In this case the subjects lived in a research metabolic ward for the extent of the experiment and were allowed no other access to food. Moreover, when forced exercise was used to increase daily energy output by 18% or 32%, the subjects mostly tended to compensate by increasing the size of all their meals and not by increasing the number of meals per day. Although Campbell and Becker's data are unusual in that they also include information on the time of "eating", their interpretation is still subject to the limitations resulting from the use of liquid diets as opposed to more common solid food.

The present study represents the first recorded attempt to examine in detail the temporal patterning of *ad libitum* solid food consumption over several weeks. Other investigators have used the diary method to examine the relationship between energy intake and expenditure in the field, but unfortunately they do not report any data on the timing or frequency of intake (e.g., Passmore, Thomson, and Warnock, 1952; Widdowson, Edholm, and McCance, 1954).[109,149] We realize that our results may be affected by certain variables which are difficult to control precisely outside the laboratory; however, we feel that the natural conditions of this study, both in terms of the types of foods and subjects' daily activities, far outweigh any possible loss of precision which might be gained in a less natural, restricted short-term hospital or laboratory setting.

Method

The basic data collection procedures for this aspect of the experiment are included in the preceding method section for food preferences and choice behavior. Tables of nutritive values based on laboratory analyses provided determinations of nutrient content for each component of the canned rations, including calories, protein, carbohydrate, and fat (Appendix C–4). Similar nutritive values (Appendix C–5a) were obtained for the frozen foods by calculations based on a combination of the following: (1) laboratory analysis of the nutrient content of the whole meal, (2) actual weight of each food item in the meal, and (3) the relative nutrient content of each food item as published in Handbook VIII by U.S.D.A. (see Appendices C–5b and C–5c).[143] The individual food log data were then converted to the corresponding amounts of calories, protein, carbohydrate, and fat consumed per item for each eating event.

Results and Discussion

The results of the nutrient intake analyses can be grouped into two major categories. The first relates only to the data collected during the *ad libitum* stages of the experiment (i.e., Stages II, III, and IV) and describes how each person's intake varied across the 24 hours of the day. The second relates to all five stages of the study and describes how much of each nutrient was consumed by a subject during a particular week or stage,

be it *ad libitum* or restricted mealtiming. Thus, the first analysis is concerned with **when** the subjects chose to eat, while the second is concerned with **how** they chose to eat.

Daily pattern of eating events. In order to examine the temporal patterning of eating throughout the day, each subject's food intake was analyzed by computer in terms of the frequency of eating and the average amount eaten during successive 2-hour intervals of the day for each 2-week *ad libitum* stage. Based on the findings of Cambell and Becker (1975),[17] meals were defined according to a 30-minute criterion. Successive periods of eating which were separated by less than 30 minutes were considered as a single meal, while those separated by 30 minutes or more were considered as two different meals. Mealtime was defined by the time when eating was initiated as recorded on the daily food log for each item eaten.

The results were then plotted for each subject as shown in Figure 2. This composite graph, or plexogram, enables comparison of the actual number of meals eaten during each 2-hour interval of the day with the average (± SE) caloric value of the meals eaten at that time. The three major sections are labeled according to the type of ration available for that two weeks with the mean daily number of meals and calories consumed listed in the upper left-hand corner.

For purposes of pattern classification, several features should be taken into account when examining these plexogram figures. First, the shape and consistency of the frequency histogram in the lower half of the figures can be used to determine whether an individual eats meals at regular times. Subject No. 5, at the top of Figure 2, adheres to fairly rigid mealtimes. His frequency distributions are trimodal with the peaks occurring at about the same time of day during each stage. For other subjects the frequency histogram is relatively flat, thus indicating that the person ate many small "meals", or snacks, throughout each day or instead ate regular-size meals but at varying times each day during the two-week span. A distinction can be made between these latter two types of eating patterns by comparing these same individuals with regard to the variation in average meal size throughout the day. For our purposes we will consider such a subject to be more of a "snacker" if he or she varies meal size substantially both within (i.e., as indicated by ± SE) and across the 2-hour intervals (i.e., greater than 200% variation in the mean caloric intake within a stage). Conversely, we will consider a subject to be more of an irregular meal-eater and less of a snacker, if he or she eats relatively constant amounts both within and across the 2-hour intervals.

Although these categorical criteria are rather arbitrary and somewhat limited in that they ignore the type of food eaten, they can prove helpful in attempting to compare individual food intake patterns. However, one must realize that individual eating patterns typically do not fit nearly into one or the other of these three defined categories. For instance, some individuals may eat regular meals but periodically snack in between them, while others may vacillate between eating regular and irregular meals. Therefore, when comparing the plexograms, the reader should use the categories merely as guidelines for interpreting each person's general eating pattern and not as rigid rules of analysis.

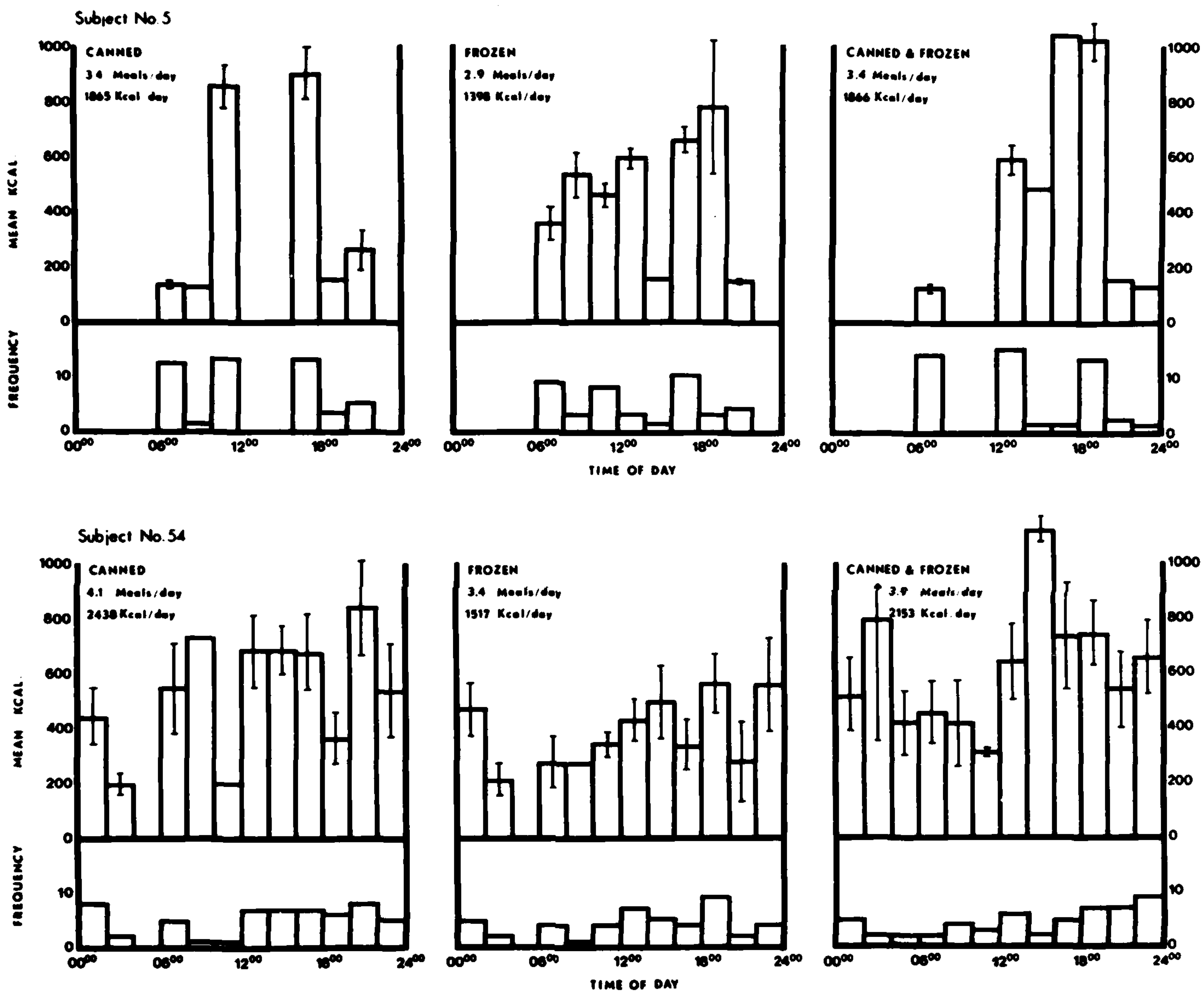


Figure 2. Variations in frequency and mean size of meals as a function of time of day for Subjects 5 and 54 during <u>ad libitum</u> stages. Vertical bars indicate standard errors of mean for meal sizes.

As can be seen in Figures 2 to 5, subjects varied from those who regularly ate three meals per day with very little variation in either the time or amount of eating to a few who ate at least once during each of the twelve 2-hour intervals and whose intake varied over 400% in calories. These individual patterns of intake appeared to be fairly rigid for most subjects since they persisted despite the biweekly changes in food type, packaging, and ease of preparation.

This rigidity is apparent in the first four figures which describe some of the more concise types of eating patterns exhibited by the subjects. Returning to Subject No. 5 in Figure 2, you can see that his frequency distributions (lower half of the graph) are trimodal for each stage and that his variations in meal size, as indicated by standard errors of the mean, are relatively small at these usual mealtimes. Thus, he typically eats 3 consistent meals per day and consumes only a few between-meal snacks per week. His pattern of eating contrasts markedly with that of Subject 54 at the bottom, who demonstrates a "snacking pattern". Although this person tends to eat about 4 times per day, he does so at all possible hours consuming highly variable amounts at different sittings. Note, that while there are some variations in the timing of some meals (Subject No. 5) or in the number of calories eaten (Subject No. 54), both subjects' typical eating patterns persist throughout all 3 stages.

Two more subjects are described in Figure 3. Subject No. 6, at the top, concentrates his eating at three or four fixed times of the day and can be characterized as a meal-eater like Subject No. 5; unlike the latter, however, he tends to consume on the average about 4 meals per day with very little variation in the amount eaten regardless of the time. Subject No. 59 at the bottom is much more of a "snacker", that is, she tends to eat at no one particular time or times. She consistently consumes more than 4 "meals" per day on the average, and eats anywhere from 200 to over 1000 kcals at a time. More important, however, is the fact that both subjects again maintain their typical eating pattern across each 2-week span. The same is true of Subjects 58 and 63 in the next two figures (Figures 4 and 5). The former eats a relatively large number (four or more) of consistently small meals per day at rather irregular times regardless of stage, while the latter also eats at a variety of different times but consumes widely varying amounts. The reader is left to examine the plexograms of the remaining subjects on his own (see Appendix D). While there are a few instances, for example Subject No. 53, where the type of food available (i.e., stage) may have affected the person's eating pattern over time, in most cases food type only affected the biweekly number of meals and calories consumed and not the pattern of eating; i.e., how meals varied in size and when they occurred throughout the day.

Hopefully more detailed statistical analyses of these data will be possible in the near future thus permitting more precise descriptions of our subjects' eating patterns in further reports. For example, cluster analyses should reveal in what ways people may be considered members of homogeneous subgroups defined by eating patterns. The key discriminating features of each group could be determined empirically and could be assessed quantitatively. Identifying and describing the relevant groups would be an important point of progress. It would provide a behavioral background against which to understand changes in food preference and body physiology.

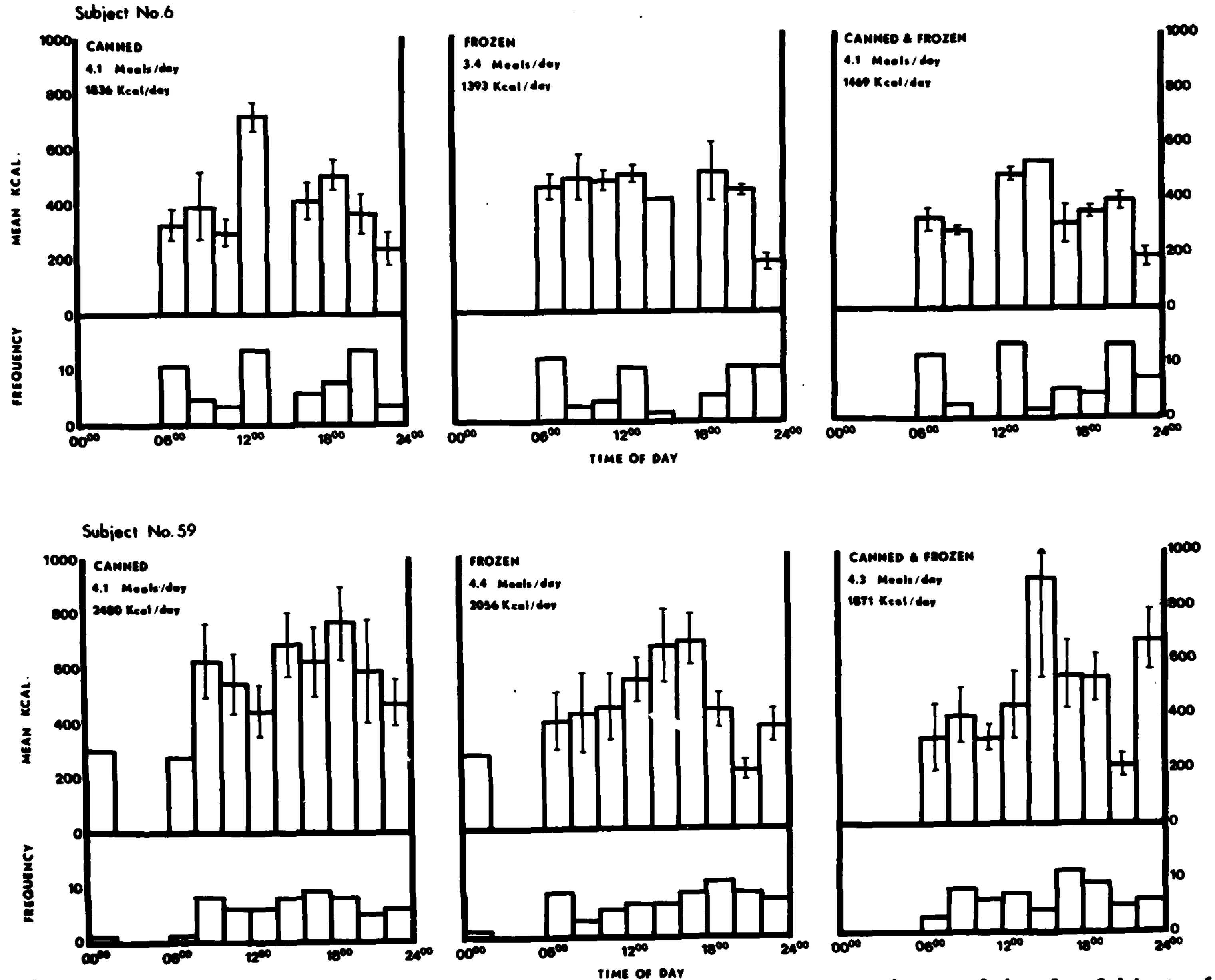


Figure 3. Variations in frequency and mean size of meals as a function of time of day for Subjects 6 and 59 during <u>ad</u> <u>libitum</u> stages. Vertical bars indicate standard errors of mean for meal sizes.

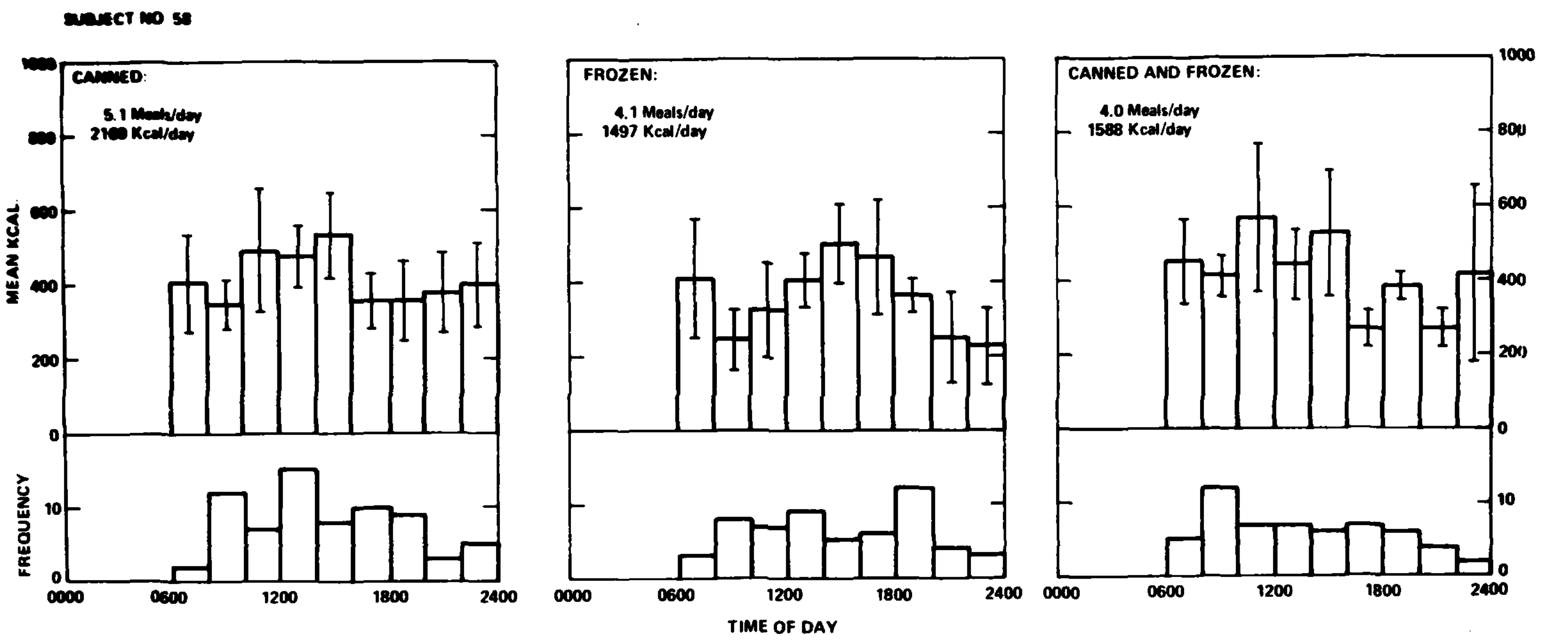


Figure 4. Variations in frequency and mean size of meals as a function of time of day for Subject 58 during ad libitum stages. Vertical bars indicate standard errors of mean for meal sizes.

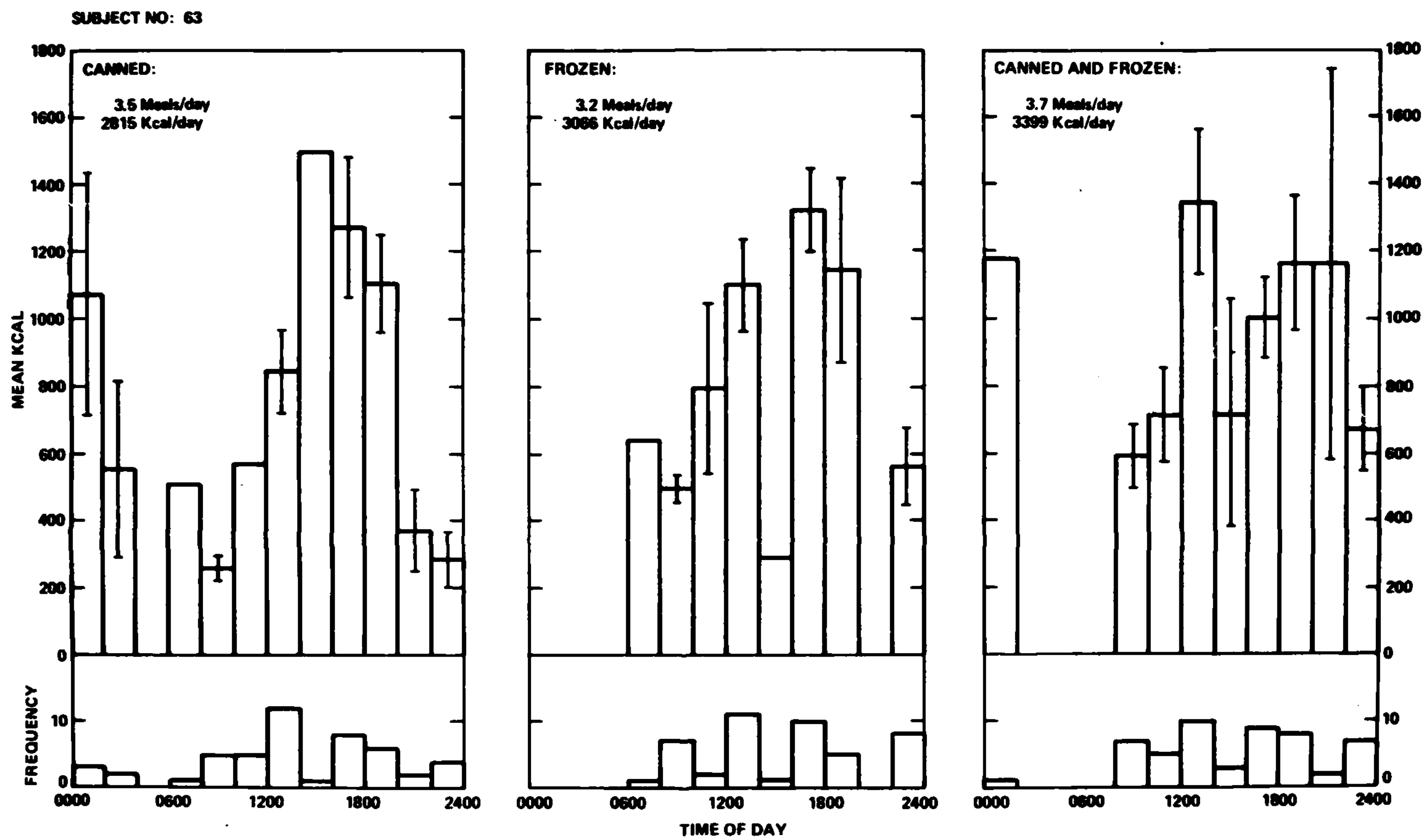


Figure 5. Variations in frequency and mean size of meals as a function of time of day for Subject 63 during _ad libitum_ stages. Vertical bars indicate standard errors of mean for meal sizes.

Variations in nutrient consumption. Examination of the mean daily intake data listed at the top of the plexograms reveals that 12 of the 18 subjects ate fewer calories when only frozen rations were available than when either the canned or combined set of rations were available. Three other subjects, as well as 10 of the same 12 individuals, also ate fewer meals during the frozen ration stage. Comments obtained from the subjects upon completion of the study (see Appendix H) suggest that this overall reduction in eating was caused by the storage and preparation requirements of the frozen meals which sometimes made it difficult to eat whenever they wished.

The major question concerning nutrient consumption is whether restricted mealtiming affects the intake of certain nutrients in different ways. The answer to this question can be seen in Figure 6 which compares the **ad libitum** intake of three major nutrients during Stage IV with that during Stages V and VI. Analyses of variance indicated that the control subjects maintained a constant level of intake across all three stages (8 weeks) for each type of nutrient while both experimental groups altered their nutrient intake depending on the stage ($p<0.001$, see Appendix G-6). Both the Breakfast-first group and Dinner-first group decreased their intake of all three nutrients during Stage V compared with that during Stage IV; however, when they changed mealtimes during Stage VI, only those subjects switching from Breakfast to Dinner tended to compensate for the preceding loss of nutrients. A significant Stage x Nutrient interaction in the analyses of variance for both groups (see Appendix G-6) suggests that Stages V and VI affected the intake of some nutrients more than others; however, this is clearly not the case. Instead, it can be seen that all three nutrients were affected equally, (except fat during V and VI for the Dinner-Breakfast group) thus maintaining a fairly constant proportionality among them, and that the statistical interaction is due to the absolute differences in grams of nutrients ingested. The fact that Stage V equally affected the intakes of both experimental groups rules out the possibility that a greater cumulative nutrient deficiency caused the Dinner group to increase its intake during Stage VI above the **ad libitum** (Stage IV) level. Rather, the results suggest that individuals may be less able to increase morning meal size than evening meal size when their daily nutrient requirements increase.

Tables 22 to 25 summarize the individual nutrient consumption data for each stage of the experiment. An examination of the individual caloric intakes during Stages IV, V, and VI demonstrates the generality of the mealtiming effect on meal size. As shown in Table 22, 8 of the 9 subjects in the Breakfast-first group increased their daily caloric intake when shifted to the Dinner-only condition (Stage VI), whereas two people in the Dinner-first group increased their caloric intake in Stage VI, and only one of these (No. 69) increased it substantially. Examination of the other three tables describing individual nutrient intake serves to confirm the overall impression gained from Figure 7. Thus, it appears that, although restricted mealtiming can produce a decrement in nutrient consumption, it does so by decreasing total daily intake and not by affecting the intake of some nutrients more than others.

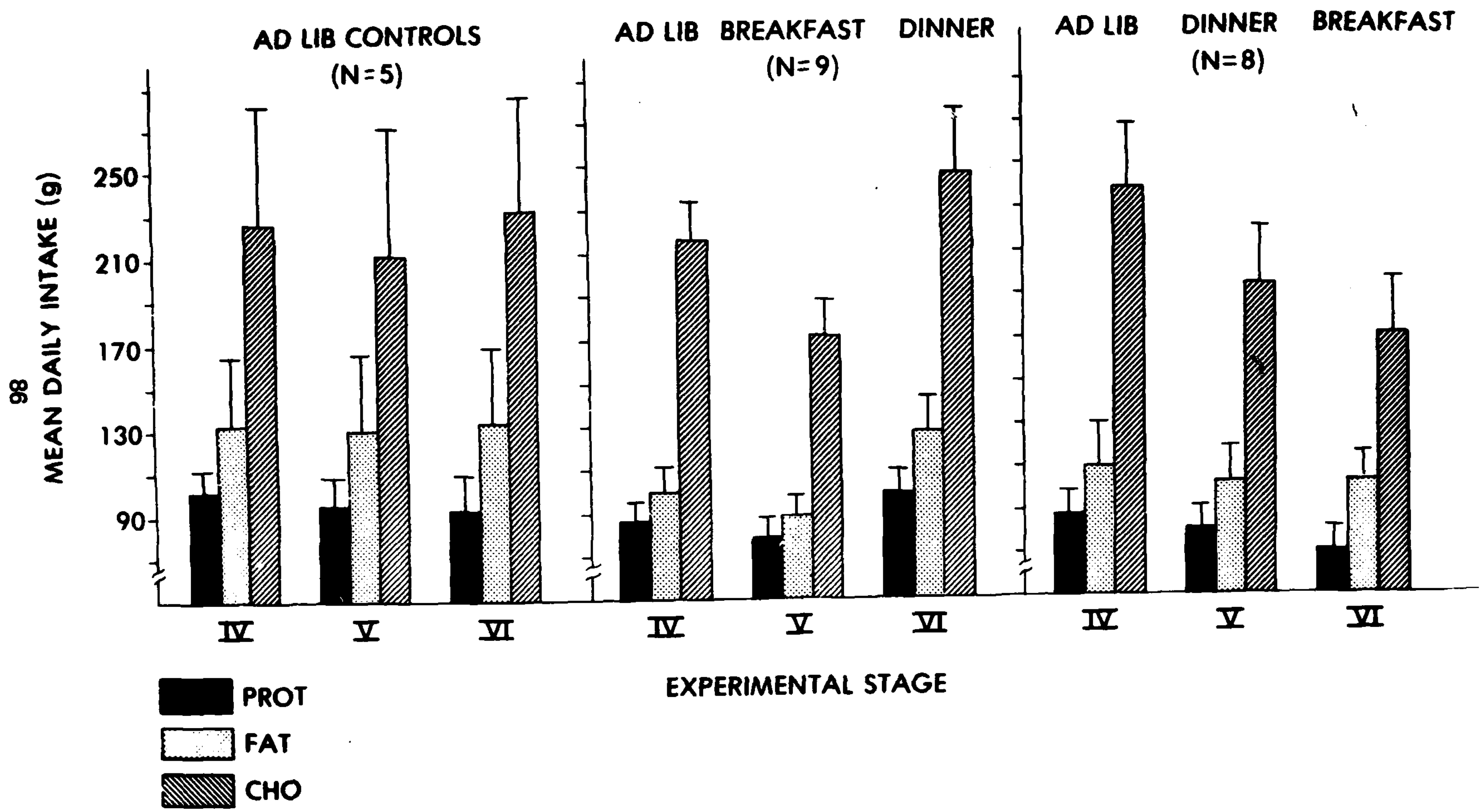


Figure 6. Mean daily nutrient intake for control and experimental subjects before and during restricted mealtime stages.

Table 22. Mean daily caloric intake (Kcal) for individuals by stage.

Mealtime Restriction	Subject	II (Ad Libitum)	III (Ad Libitum)	IV (Ad Libitum)	IVa	V (Restricted)	VI (Restricted)
Ad Libitum	3	920	1352	1143	----	1171	1187
	6	1836	1393	1469	----	1587	1612
	55	2484	2087	2172	----	----	----
	56	1557	815	1396	2061	1338	1748
	63	2815	3066	3399	----	3301	2588
	70	----	----	----	3034	3474	3961
Breakfast First	2	1877	1206	1408	----	1024	1278
	5	1865	1398	1866	----	1914	1864
	51	2368	3196	2970	3170	2153	3151
	54	1517	2438	2153	2441	2401	3751
	58	2160	1499	1588	----	1127	1547
	59	2056	2480	1871	2212	1331	2314
	64	1817	2006	2250	2347	1852	2368
	66	----	----	----	2037	2021	2791
	72	----	----	----	1522	1392	2301
Dinner First	1[b]	1521	2218	2442	----	2143	2004
	4	1601	1591	1478	----	1267	726
	53	3346	1490	2723	2416	2434	1943
	57[c]	1683	2156	1502	----	----	----
	61	1343	2154	2188	2439	1774	1347
	62	2272	2791	1863	2148	1834	1935
	68	----	----	----	1316	1400	1384
	69	----	----	----	1538	912	1468
	70[d]	----	----	----	3961	3238	3098

[a]Stage IV was repeated or experienced later by some subjects, as explained in the method section for Food Preference and Choice Behavior. (Also see Figure A-1, Appendix A.)

[b]Subject varied greatly from mealtime restriction guidelines during Stages V and VI.

[c]Subject's intake not reported for Stages V and VI because of emotional difficulties at that time and consequent unreliability of food log records.

[d]Subject repeated Stages V and VI after first completing them *ad libitum*; Stage IV data corresponds to Stage VI as *ad lib*.

Table 23. Mean daily fat intake (g) for individuals by stage.

		STAGE					
		Ad Libitum				Restricted	
Mealtime Restriction	Subject	II	III	IV	IV[a]	V	VI
	3	54.1	80.6	75.1	-----	69.7	75.1
	6	86.1	79.0	73.1	-----	76.5	77.9
Ad Libitum	55	125.4	144.1	110.3	-----	-----	-----
	56	70.3	50.3	67.9	101.5	72.0	85.3
	63	165.4	252.9	234.4	-----	209.6	179.9
	70	-----	-----	-----	179.8	225.0	248.1
	2	83.9	59.6	60.8	-----	48.3	63.0
	5	96.2	93.1	108.7	-----	104.8	100.6
	51	165.6	170.7	174.0	179.0	123.4	182.9
Breakfast First	54	91.0	110.0	118.2	116.8	121.0	209.5
	58	123.9	95.3	84.3	-----	59.7	76.1
	59	140.3	133.4	103.1	119.2	68.0	121.3
	64		143.1	126.8	141.7	95.9	132.5
	66	-----	-----	-----	114.0	110.1	157.1
	72	-----	-----	-----	71.7	66.9	106.3
	1[b]	100.1	109.8	120.8	-----	108.1	104.1
	4	101.3	95.2	83.8	-----	70.0	45.5
	53	156.1	88.9	137.9	123.6	126.5	109.4
	57[c]	102.9	131.1	90.9	-----	-----	-----
Dinner First	61	69.4	113.5	101.9	98.6	74.7	84.5
	62	163.9	143.4	117.7	134.3	114.4	117.4
	68	-----	-----	-----	63.8	86.8	89.3
	69	-----	-----	-----	71.5	36.8	93.7
	70[d]	-----	-----	-----	248.1	188.4	166.9

[a]Stage IV was repeated or experienced later by some subjects, as explained in the method section for Food Preference and Choice Behavior. (Also see Figure A-1, Appendix A.)

[b]Subject varied greatly from mealtime restriction guidelines during Stages V and VI.

[c]Subject's intake not reported for Stages " and VI because of emotional difficulties at that time and consequent unreliability of food log records.

[d]Subject repeated Stages V and VI after first completing them <u>ad libitum</u>; Stage IV data corresponds to Stage VI as <u>ad lib</u>.

Table 24. Mean daily carbohydrate intake (g) for individuals by stage.

		STAGE					
		Ad Libitum				Restricted	
Mealtime Restriction	Subject	II	III	IV	IV[a]	V	VI
Ad Libitum	3	58.9	134.1	77.2	-----	82.3	79.6
	6	208.6	89.1	121.9	-----	144.0	157.9
	55	270.4	145.9	206.6	-----	-----	-----
	56	200.9	59.4	158.6	221.8	129.0	190.8
	63	317.6	274.1	385.3	-----	394.0	315.0
	70	-----	-----	-----	274.3	309.3	363.4
Breakfast First	2	205.7	75.4	142.8	-----	83.5	109.3
	5	195.8	97.5	175.9	-----	186.9	184.8
	51	148.4	334.8	285.2	293.8	208.5	262.7
	54	100.4	294.4	207.9	292.8	238.5	413.0
	58	228.8	115.0	174.9	-----	115.8	167.1
	59	155.6	280.9	184.0	248.8	151.8	264.7
	64		142.1	245.3	231.4	184.6	239.7
	66	-----	-----	-----	218.5	222.3	295.0
	72	-----	-----	-----	175.3	160.0	288.9
Dinner First	1[b]	105.9	277.7	272.4	-----	238.9	202.7
	4	105.4	138.9	132.5	-----	115.0	51.3
	53	392.1	68.9	301.4	265.4	245.4	229.7
	57[c]	118.8	237.4	127.7	-----	-----	-----
	61	92.6	229.9	262.9	323.0	198.9	109.0
	62	141.3	319.7	161.0	204.7	146.0	189.0
	68	-----	-----	-----	154.7	150.5	143.6
	69	-----	-----	-----	182.5	115.5	134.0
	70[d]	-----	-----	-----	363.4	326.7	287.6

[a]Stage IV was repeated or experienced later by some subjects, as explained in the method section for Food Preference and Choice Behavior. (Also see Figure A-1, Appendix A.)

[b]Subject varied greatly from mealtime restriction guidelines during Stages V and VI.

[c]Subject's intake not reported for Stages V and VI because of emotional difficulties at that time and consequent unreliability of food log records.

[d]Subject repeated Stages V and VI after first completing them ad libitum; Stage IV data corresponds to Stage VI as ad lib.

Table 25. Mean daily protein intake (g) for individuals by stage.

		STAGE					
		Ad Libitum				Restricted	
Mealtime Restriction	Subject	II	III	IV	IV[a]	V	VI
	3	65.0	58.2	72.1	-----	77.6	77.0
	6	76.4	97.9	93.2	-----	91.6	83.2
Ad Libitum	55	97.4	123.1	105.8	-----	-----	-----
	56	46.1	51.1	52.5	91.7	63.6	77.4
	63	106.2	137.6	113.3	-----	102.3	68.0
	70	-----	-----	-----	137.0	139.8	156.7
	2	85.4	95.9	79.2	-----	65.3	72.3
	5	82.0	88.6	88.1	-----	93.0	90.5
	51	135.9	129.2	127.0	140.3	100.2	149.8
Breakfast First	54	118.1	95.6	101.2	100.8	127.1	155.2
	58	84.8	90.9	66.7	-----	51.5	65.7
	59	107.9	86.4	82.4	81.3	48.4	83.2
	64		114.4	95.3	98.6	96.1	98.2
	66	-----	-----	-----	64.8	72.9	106.8
	72	-----	-----	-----	60.3	55.6	75.5
	1[b]	100.1	71.6	98.5	-----	93.9	84.2
	4	102.5	72.4	67.6	-----	63.2	33.8
	53	121.0	114.4	97.1	84.6	94.4	45.3
	57[c]	114.5	72.0	81.1	-----	-----	-----
Dinner First	61	87.6	82.8	75.8	75.8	77.0	61.2
	62	122.8	102.1	76.6	87.3	90.4	80.1
	68	-----	-----	-----	55.1	49.9	51.0
	69	-----	-----	-----	59.5	36.9	56.0
	70[d]	-----	-----	-----	156.7	129.0	134.7

[a]Stage IV was repeated or experienced later by some subjects, as explained in the method section for Food Preference and Choice Behavior. (Also see Figure A-1, Appendix A.)

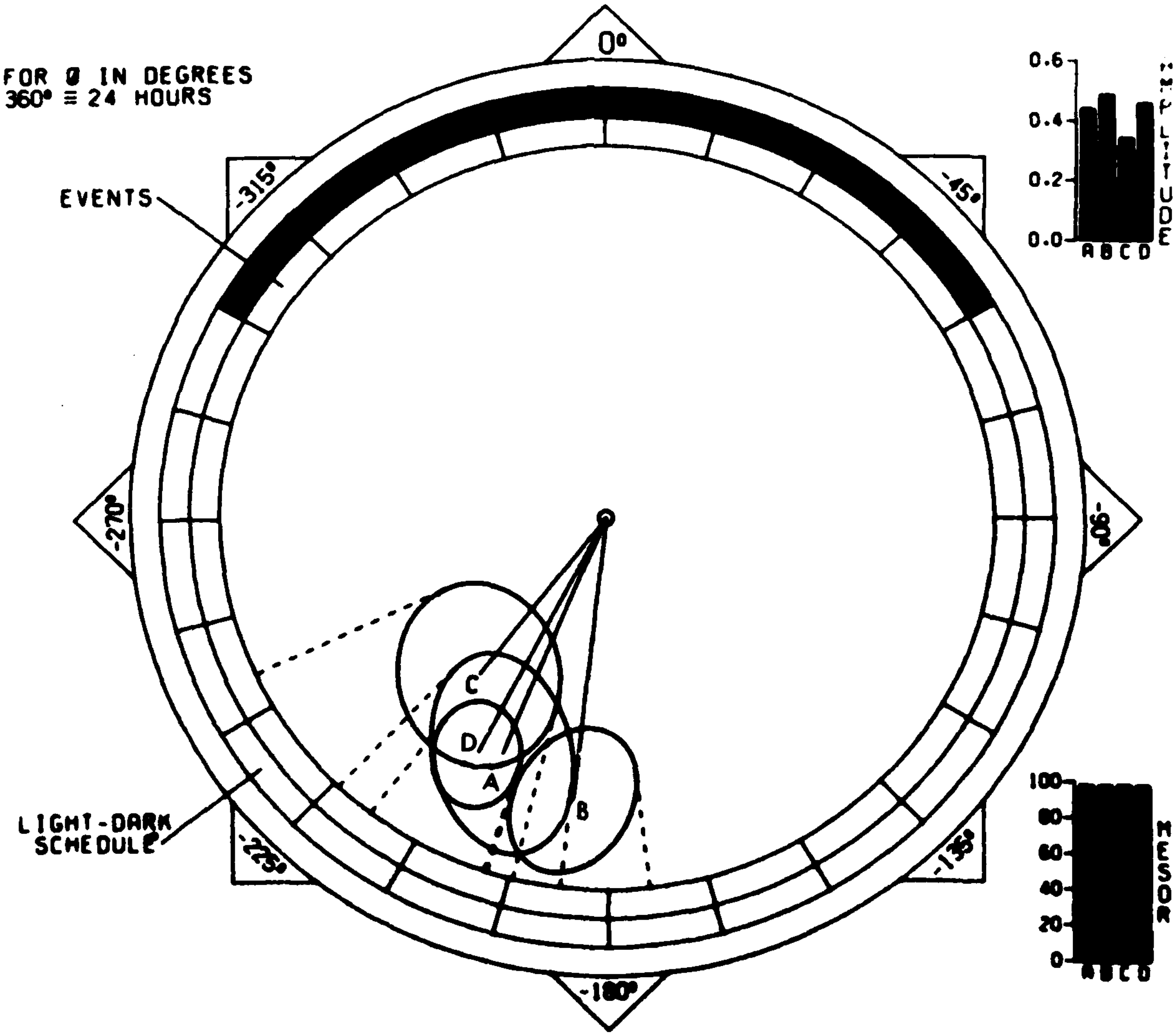
[b]Subject varied greatly from mealtime restriction guidelines during Stages V and VI.

[c]Subject's intake not reported for Stages V and VI because of emotional difficulties at that time and consequent unreliability of food log records.

[d]Subject repeated Stages V and VI after first completing them ad libitum; Stage IV data corresponds to Stage VI as ad lib.

FIGURE 7

CIRCADIAN RHYTHM IN ORAL TEMP OF SUBJS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	98	0.44 (0.29 0.60)	-203 (-187 -224)
B BRKFST ONLY	<0.001		19	98	0.49 (0.36 0.62)	-187 (-174 -198)
C DINNER ONLY	<0.001		19	98	0.34 (0.20 0.49)	-218 (-194 -246)
D CONTROLS	<0.001		17	98	0.46 (0.37 0.55)	-208 (-199 -218)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

CHRONOBIOLOGY LABORATORIES UNIVERSITY OF MINNESOTA
MINNEAPOLIS MINNESOTA 55455 USA PHONE (617) 373-2920

Conclusions

1. Subjects varied from those who could be characterized as being predominantly "snackers" or "nibblers" to those who regularly ate three standard-size meals per day.

2. Most subjects maintained a fairly stable pattern of eating throughout the ad libitum stages both in terms of the frequency and timing of eating and the size of meals eaten.

3. Food type, along with associated packaging and preparation differences, affected only the total biweekly number of meals and calories consumed and not the typical size of meals and when they tended to occur throughout the day.

4. Restricted mealtiming affected the intake of protein, carbohydrate, and fat equally, decreasing each by the same proportional amount during the first three-week stage of restriction. The resultant decrement in nutrient consumption was the result of a decrease in total daily food intake and was not specific to any particular nutrient.

5. Only those subjects eating Dinner-only during the second three weeks of mealtime restriction increased their nutrient intake above ad libitum levels perhaps to compensate for losses during the first three weeks of restriction. Whether this effect constitutes a "compensation" or not remains to be established. If it is, one might infer that diurnally active, nocturnally resting individuals are less able to increase morning meal size than evening meal size when their daily nutrient requirements increase.

TASK PERFORMANCE, BIORHYTHMS, AND BODY WEIGHT CHANGE

Problem

The relationship between diet and good health is a primary concern for all of us. In the military, this concern has been translated into attempts to optimize troop performance by guaranteeing good nutrition. The role of physiology in determining the final operational outcome is often ignored insofar as the soldier is physically fit and eating well-balanced meals. Presumably, such a person would be at his physiological best when called upon to perform. This assumption precludes the influence of circadian variations in physiological states.

The presence of circadian rhythms among physiological functions is now well known. The extensive literature on this topic has demonstrated significant variations throughout the day in the functioning of almost all major human organ systems including the endocrine and central nervous systems. Likewise, individual performance capacity has been shown to vary in a circadian fashion. Thus, although a soldier may be very well nourished and physically fit, his ability to perform will depend upon the time of day.

By manipulating the timing of a person's meals, it may be possible to shift his physiological circadian rhythms and thereby alter the time of peak performance capacity to correspond with performance requirements. As documented in the following review, there is substantial evidence from animal research to support such a notion. There is also reason to believe that the time of eating may affect the nutritional consequences of a meal. Hypothetically, if the military were to capitalize on such a phenomenon, it would be able to provide more optimal nutrition to its troops by controlling the time at which food is served in the dining hall, rather than by merely controlling what is served. Both of these potential effects of mealtiming on humans are investigated in this section of the report.

Moreover, the results covered here are tangentially related to those discussed in the earlier section dealing with food preference and choice behavior. As Pilgrim (1957) has pointed out,[113] the problems of food consumption and preference cannot be divorced, without much waste, from the very physiology which underlies them. Until recently, there has been a distinct lack of concern for determining how circadian rhythms might affect food preferences. In the extreme case, one hardly appreciates being awakened just after falling asleep and being asked what he or she prefers to eat. Just sleeping then seems preferable to the best steak. By the same token, many food preference tests may be carried out in ignorance of dramatic bodily changes that may exceed in consequence the difference between the wakeing and sleeping states. As a first step in assessing this problem, the present study provides a unique opportunity for exploring individual food preferences and consumption in relation to a variety of circadian rhythms.

Review of Literature

Circadian rhythmicity characterizes most, if not all, biological phenomena. In mammals such important variables as hormones affecting growth, development, and the organism's response to disturbance, exhibit pronounced circadian rhythms in body fluids (Lakatua, et al., 1974; Halberg, 1969).[83,52] Such rhythms can also determine long-term as well as short-term chances for survival of animals challenged with harmful agents. For example, susceptibility of mice to chemical carcinogenesis depends to an appreciable extent on the timing of the chemical's application during a 24-hour span, although pathology and death may not occur until months later (Mottram, 1945; Halberg, 1964; Frie, 1964; Iverson, et al., 1970).[99,51,36,70]

Long-term developmental and reproductive changes in many animal and plant pecies also appear to depend on circadian "timing" (Halberg, 1960; Pizzarello, et al., 1964; Garcia–Sainz, et al., 1968; Haus, et al., 1973; Meier, 1973; Bunning, 1969; Elliott, et al., 1972; Truman, 1973; Hamner and Takimoto, 1964).[50,116,41,64,91,16,28,141,59] It seems reasonable, therefore to suggest that long-term changes associated with fitness and survival (Nelson, Cadotte and Halberg, 1973) may have some relation to the rhythmic changes which every organism undergoes daily and that factors which affect these rhythms can not only alter lifespan,[101] but also improve life quality. Except for a few notable instances (Iowa Breakfast Studies, 1962),[69a] the importance of mealtiming as such a factor has been seriously neglected.

Reports from various sources indicate that optimal nutrition depends not only on **what** is eaten and **how much** is eaten, but also on **when** it is eaten during the day. More specifically, a within-day variation in caloric requirements is not completely explained by the 24-hour activity-rest cycle although the latter may, to a large extent, determine the optimal time for meals. Circadian rhythms in basal metabolism have been described for man (Bornstein and Volker, 1926; Apfelbaum, et al., 1971) as well as for laboratory animals (Heusner, 1963).[102,65] A study on rats (Bare, 1959) indicates furthermore that "hunger" (measured by the rate of bar-pressing for food) is not solely a function of the time elapsed since the last meal but varies according to a circadian rhythm.[6] Moreover, a circadian rhythm in murine liver glycogen content, long considered to be merely a reflection of the feeding schedule, persists even in complete starvation (Haus and Halberg, 1966),[63] suggesting the continuation of a cyclic "commerce" in energy stores, presumably in response to fluctuating endogenous as well as exogenous needs.

Other evidence also points to cyclic changes in the body's utilization of food. A circadian rhythm in respiratory quotient (RQ), demonstrated for normally-fed and calorie-restricted women (Apfelbaum, et al., 1971)[2] suggests a variation in the kinds of nutrients metabolized. The highest RQ occurred about noon, indicating perhaps a greater combustion of carbohydrate at that time. Within-day variation in oral glucose tolerance (Bowen and Reeves, 1967; Jarrett, in press)[12] also points to a rhythm in the disposition of ingested carbohydrate, possibly due to changes in absorption, distribution and excretion, as well as in metabolism, as a result of hormonal rhythms (Gagliardino and Hernandez, 1971; Lakatua, et al., 1974).[40,83]

Metabolism of the amino acid, tryptophan, has been reported to be greatest in man during the morning and least during the evening (Rapoport and Beisel, 1968).[119] A circadian rhythm in the metabolism of another amino acid, tyrosine, by mice, led to the conclusion "that the proportion of the tyrosine in a given amount of food which remains available to the body for utilization in the synthesis of endogenous protein depends upon the hour of its ingestion" (Wurtman, 1970).[150] Earlier work indicated that the effect of changes in dietary protein content on hepatic enzyme activity in rats varies during a 24-hour span (Potter, et al., 1966).[118]

Numerous studies have examined the effects of a single daily meal in laboratory animals. When feeding by rats is restricted to a limited time span (e.g., 2 hours) each day, rates of fat and carbohydrate metabolism are increased as compared to animals feeding *ad libitum* (Hollifield and Parson, 1962; Leveille and O'hea, 1967; Leveille and Chakrabarty, 1967; Fabry, 1967).[68,88,87,31] In many of these studies access to food was permitted only during the early part of the working day, a timing presumably selected for the convenience of the investigator. The importance of this factor was dramatically demonstrated by a recent study on the short-term survival rates of mice abruptly restricted to a single daily "meal" (Nelson, Cadotte, and Halberg, 1973).[101] If feeding was permitted for 4 hours in early darkness most of the animals survived, but if food was accessible only during 4 hours in the early light span most of the animals died. Environmental temperature and other conditions affecting body heat loss (grouping of animals, cage design) were found to influence the outcome of such studies. This qualification does not, however, detract from the demonstration that the timing of food accessibility in relation to other periodic factors confronting the mammal can be critical. Similar findings have been reported for rats restricted to 2-hour meals during the light or dark. Although they survived the ten days of the experiment, those animals fed during the light span did not adapt as well to restricted feeding as indicated by a longer latency to eat, lower food intake and body weight, and decreased insulin levels in comparison to those rats fed in the dark (Balagura, Harrell, and Roy, 1975).[4]

Food accessibility has long been recognized as a synchronizer of circadian rhythms, although subordinate to lighting regimen, in the case of freely feeding mice and rats (Halberg, 1953; Halberg, Visscher, and Bittner, 1953; Halberg, 1959).[48,56,49] Ordinarily, these rodents consume most of their food during the dark stage of the daily lighting regimen. Fuller and coworkers (Fuller and Snoddy, 1968; Fuller and Diller, 1970)[37,38] demonstrated that when rats were allowed to feed only during the early light span the timing of circadian rhythms in plasma-free fatty acids, liver glycogen, and tyrosine-transaminase activity were changed. They recognized that: "It was probably not meal-feeding *per se* that caused shifts in glycogen and free fatty acid rhythms; instead the shifts occurred because the meal was fed during the day rather than at night". Other work has also indicated that, if the rodent is restricted to a defined short feeding span daily and thus to limited food consumption, feeding time assumes an important role in determining the temporal placement of rhythms in counts of blood eosinophil cells (Halberg, Visscher, and Bittner, 1953),[56] in CO_2 emission (Stupfel, Halberg, and Halberg, 1973),[138] and in telemetered core temperature (Nelson, et al., 1973),[103] among other

variables (Hopkins, et al., 1973, Nelson, Scheving, and Halberg, 1975).[69,104] Differential mealtiming effects were also found by Scheving et al. (unpublished data) upon the H^3 thymidine uptake into DNA of murine bone marrow,[123a] tongue, gut, spleen, and testes and upon liver RNA content, as well as on hepatic malic acid dehydrogenase--an enzyme essential to anaerobic glycolysis. Consequently, relations among the body's variables at different times during a 24-hour span will differ not only, and not even primarily, as a function of whether mice are meal-fed or fed *ad libitum* but will depend rather heavily on whether the "meal" is permitted at one or another time, defined by the stage of the light-dark regimen.

In the case of man, many investigators consider the consumption of all or most of one's daily food during a single large meal ("gorging") detrimental to health, possibly resulting in artherosclerosis and diabetes (Bortz, Howat, and Holmes, 1969; Cohn, 1964).[11,20] The possible role of such a meal's timing in relation to other schedules and demands has largely been ignored, except perhaps for the statement: "A high percentage of the American population places a tremendous burden on their nutrient-disposing-of system by consuming 50% to 75% of their food intake at the evening meal, at a time when energy expenditure for the day is at a low ebb" (Cohn, 1964).[20] Stunkard and his colleagues have shown that this phenomenon is especially characteristic of obese individuals, many of whom exhibit a pronounced "night-eating syndrome" (Stunkard, Grace, and Wolff, 1955).[137]

The increased longevity of rats and mice on schedules of alternate feeding and fasting may be due to the overall reduced food intake on such schedules (Leveille, 1972; Holeckova and Chvapil, 1965)[86,67] in keeping with the interpretation of McCay and others (McCay, Crowell, Maynard, 1935; Simms, 1967; Ross, 1969; Nolen, 1972; Lee, 1956).[90,133,123,105,84] On the other hand, the increased lifespan observed in animals whose food intake is reduced may be due to the intermittency of feeding, since the food provided is probably consumed quickly (Cohn and Joseph, 1967; Schnakenberg, Krabill, and Weiser, 1971).[21,124] The increase in the rates of fat and carbohydrate metabolism observed in animals consuming large meals with intervening fasting (Hollifield and Parson, 1962; Leveille and O'hea, 1967; Leveille and Chakrabarty, 1967; Fabry, 1967)[68,88,87,31] has led Yager et al. (1974) to suggest that "...forced utilization of metabolic capacities not fully employed by the *ad libitum* animal (may) contribute to survival."[151] In other words, the increase in lifespan observed in animals on reduced food intake, or fed intermittently by design, could be due to this (periodic) forcing of metabolism rather than to reduced intake *per se*.

Perhaps this alternate explanation is related to findings mentioned above (Fuller and Snoddy, 1968; Fuller and Diller, 1970; Stupfel, Halberg, and Halberg, 1973; Nelson, et al., 1973, Hopkins, et al., 1973; Nelson, Scheving, and Halberg; 1975)[37,38,138,101,69,104] indicating that circadian rhythms are altered in animals restricted to a single short span of food accessibility each day. In studies on mice (Nelson, et al., 1973; Nelson, Scheving, and Halberg, 1975),[103,104] body temperature, serum corticosterone, and liver glycogen exhibited a considerably greater amplitude of circadian variation on a periodic feeding

schedule than when food was available *ad libitum*. A concomitant increase was also seen in the 24-hour average concentration of corticosterone and glycogen. Manipulating the timing of the meal in relation to the lighting schedule (i.e., whether feeding was permitted early in the daily light span or in early darkness) produced a marked effect on the internal as well as external timing of circadian rhythms in body core temperature and serum corticosterone, on the pattern of highest values in the corneal mitotic index (Nelson, Scheving, and Halberg, 1975),[104] and even upon a susceptibility-resistance cycle to a carcinostatic drug, adriamycin (Nelson, Halberg, and Scheving, in press).[102] Mice restricted to feeding in early darkness also weighed significantly less than those feeding in early light despite no significant differences in their food intake (Nelson, Scheving, and Halberg, 1975).[104] That is, allowing these nocturnal animals to eat only at the beginning of their usual span of activity resulted in a lower body weight than was the case when feeding was permitted in early light, at which time, under *ad libitum* conditions, mice tend to be inactive. Other related research on rodents has shown that alterations in mealtiming can affect both the amplitude and timing of the circadian rhythms for various digestive enzymes (Reinberg, 1974; Stevenson, et al., 1977).[120,136]

Taken together, these studies suggest that nutrient metabolism may be altered by mealtiming either to the benefit or detriment of the organism. It is therefore tempting to speculate that a partial explanation of the wide degree of variability observed in individual human energy requirements (Kekwick and Pawan, 1969; Durnin, et al., 1973)[80,23] may lie in a better understanding of the relationship between energy utilization and physiological circadian rhythms. It has been suggested that certain cultural groups may require less energy because they have somehow adapted to being healthy and active on below-standard energy intakes (Durnin, et al., 1973).[23] Such adaptation may take the form of optimal mealtiming and, consequently, optimal physiological rhythms.

Furthermore, the effects of mealtiming on circadian rhythms and their interrelations may fundamentally alter not only lifespan, but also life quality. For example, available evidence indicates that the amplitude of at least some circadian rhythms is reduced in old rats and mice allowed to feed at will (Halberg, et al., 1955; Yunis, 1974).[53,153] Conversely, rats have been observed to live longer if fasted every third day, with free access to food on the intervening days (Carlson and Hoelzel, 1946).[19] More recently, Leveille (1972)[86] found that "meal-feeding", i.e., restriction of food accessibility to a single short timespan each day, also prolongs the rat's life. However, he did not test the effect upon lifespan of meal-feeding at different times during a 24-hour span. Conceivably, the "amplification" of certain circadian rhythms by meal-feeding counteracts a decline with age, thereby not only extending the lifespan but also assuring higher body temperatures--and thus, perhaps, better performance--during the usual daily activity span.

Method

The data on circadian rhythms were gathered primarily by a set of physiological and behavioral self-measurements performed daily by each subject every 2 to 3 hours during the waking state. The physiological variables included oral temperature, pulse,

blood pressure, and body weight, although the latter was typically not measured as often as the others. There were 6 behavioral measures including grip strength for both hands using a portable dynamometer, a single finger-counting task using the thumb of the right hand to successively contact each finger as fast as possible up to a count of 50, a random digit addition task using 50-digit pairs in a column, a modified paper-and-pen reciprocal Fitts tapping task (Fitts, 1954; Graeber, et al., 1977),[34,44] and estimates of vigor and mood along 7-point scales. A stopwatch was used to measure latency of performance for the counting, addition, and tapping tasks. Further details on the self-measurement procedures are given in Appendix E–1. After a few days of practice, all the subjects were able to perform this series of self-measurements within less than 10 minutes.

In addition, they reported to a hospital clinic at the end of the *ad libitum* phase (Stage IV) and at the end of each of the 3-week periods of mealtime restriction. Blood and urine samples were then taken every 4 hours during the next 24 hours for subsequent laboratory analyses. For the blood these included a white blood cell and lymphocyte count as well as a determination of serum iron levels (Nelson, 1964),[100] plasma growth hormone (by radioimmunoassay), plasma insulin (by radioimmunoassay), cortisol (by fluorometry), blood urea nitrogen (BUN, by diacetyl monoxime), and serum chloride (by Scheels and Scheels standard technique).

The self-measurement data as well as the blood and urine composition data were then statistically analyzed for the presence of circadian rhythms. To accomplish this, both the individual and group data for each variable were first keypunched and then tested by computer for goodness-of-fit to a cosine function having a 24-hour period (Halberg, Tong, and Johnson, 1967; Halberg, Johnson, Nelson, Runge, and Sothern, 1972).[55,54] In addition, Hotelling's T^2 analysis was performed on the self-measurement acrophases, or peak times (see Glossary), as determined by the individual cosine functions. These analyses revealed whether there were significant shifts in the timing (i.e., phase shifts) of the corresponding circadian rhythms in the experimental subjects under the *ad libitum*, breakfast-only, and dinner-only conditions.

Results and Discussion

A thorough understanding of the various effects resulting from shifts in mealtiming requires the presentation of both group and individual data. To facilitate the reader's comprehension of the rather wide range of findings, we have organized the results into four different sections according to the type of dependent variable under study. The first two deal with the findings obtained through the sets of physiological and behavioral self-measurements used in autorhythmometry (see Glossary). The third section is closely related to the first two and relates the effects of mealtiming on hormonal and other biochemical rhythms. The final section presents the results concerning changes in body weight.

Physiological self-measurements. In general, shifts in mealtiming produced changes in the timing of the acrophases for most self-measured physiological circadian rhythms;

however, the direction and degree of phase shift depended on the nature of the physiological index being measured. These results are summarized in tabular form in Table 26, but they are best illustrated by a series of polar plots (see Glossary) for each group of subjects or for each experimental condition.

Figure 7 demonstrates the results for oral temperature and will initially serve to help the reader learn how to interpret such figures. The characteristics of the polar plot are determined from the results of a mean cosinor analysis which tests the occurrence of a group-synchronized circadian rhythm using a 24-hour cosine function as a model, thereby lending the alternative name "cosinor clock" to the figure. In each case, the polar plots shown here are based on cosinor summaries of the last week of each Stage (IV, V, and VI) of the experiment.

The 360° around the circumference of the plot equal 24 hours, thus every 15° is equivalent to one hour. The black segment in the middle circular scale represents the time during which lights were off in the bedroom, thus indicating when the subject was presumably sleeping. In most of the following polar plots, the results have been plotted in reference to the midpoint of the group's time of lights-off; therefore, the center of the black span is located at 0°. Thus, this procedure plots the external acrophase (see Glossary) and allows for comparison of subjects with different sleeping habits.

The vectors, or cosinor clock hands, in the polar plots point to the time from mid-lights-off (or from some other specified reference point) at which each group's rhythm peaked for the particular variable being measured. That is, the direction of the vector indicates that rhythm's acrophase, and the length of a vector represents its amplitude. The ellipse drawn around the endpoint of each vector indicates the unexplained statistical variability of the data and therefore is known as the error ellipse (see Glossary). If the error ellipse overlaps the center (pole) of the plot, a statistically significant group circadian rhythm is not indicated. When such a significant circadian rhythm is present, as in the case of Figure 7, the dotted or dashed tangents to each error ellipse extend to define the 95% confidence arc (see Glossary) for that rhythm's statistically estimated acrophase.

Some of the following polar plots illustrate the circadian rhythms of different subject groups for one type of measurement (as for oral temperature in Figure 7), while other plots depict the circadian rhythms of one group for several different types of measurements (as in Figure 18). The first type of plot allows you to readily compare the effects of different shifts in mealtiming on a particular variable, while the second type allows you to compare the effects of a particular shift in mealtiming on the circadian rhythms of several variables in the same subjects. In either case it is important to read the legend carefully before making any interpretations. It should also be noted that each vector for the *ad libitum* control group is based on the last week of each of the final three stages (i.e., IV, V, and VI) resulting in an N of 17.

Table 26. **Acrophase Changes of Group Physiological and Behavioral Performances under Mealtime Restrictions (N=19).**

	Acrophase (degrees from midsleep)			
		Changes from *Ad Lib.* Condition		
	Ad Lib.	Breakfast-Only		Dinner-Only
Oral Temp.	-203°	+16°	*	-15°
Pulse	-193	+58	*	-77
Syst. B.P.	-206	-10		-45
Diast. B.P.	-181	-74	*	+19
Adding Speed	-186	+ 3		-19
Tapping Speed	-178	- 4		+16
Finger Count.	-190	+ 5		+ 7
Rt. Grip	-198	-18		- 6
Left Grip	-196	-10		- 3
Mood	-162	-40		-10
Vigor	-161	-12		- 5

Underlined changes are significantly different from *ad lib.* stage, $p < 0.05$, F-test.

* Difference between Breakfast-Only and Dinner-Only stages is significant, $p < 0.05$, F-test.

N=18 for adding speed, tapping speed, and finger counting.

In summary, then, you can think of the polar plots as clocks, usually with "midsleep"(i.e., lights-off) at the top, and each vector as a clock hand pointing to the time at which a particular circadian rhythm reaches its maximum value for the day. The length of the clock hand is proportional to the relative extent of regular daily variation (i.e., the amplitude) of the circadian rhythm, while the width of the ellipse tells you how accurately the 24-hour cosine function describes the data; the smaller the ellipse, the better the fit.

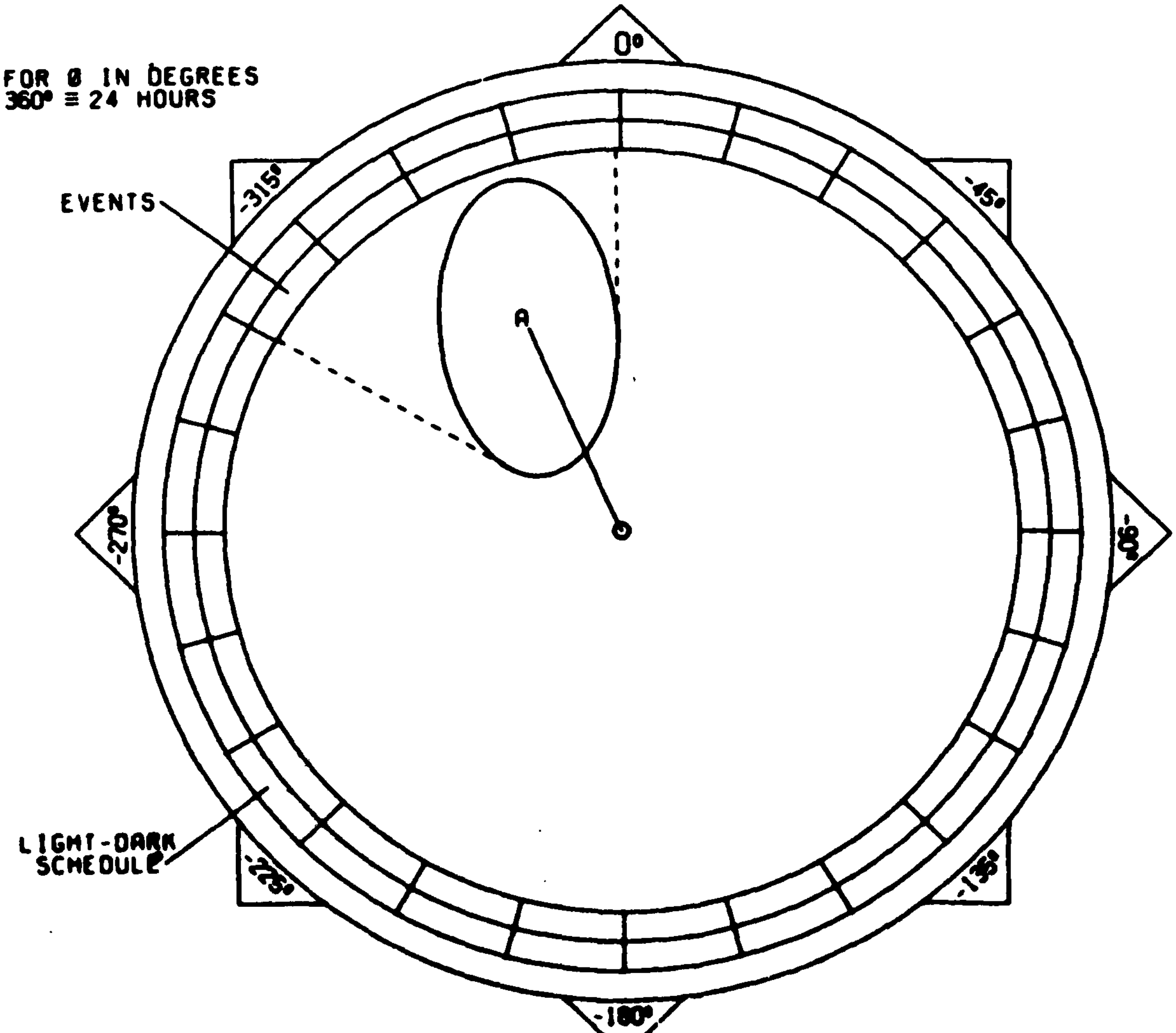
As Figure 7 indicates, the oral temperature rhythms were almost identical for the *ad libitum* control group (indicated by the D vector) and for the experimental subjects during the *ad libitum* Stage IV (A vector). The effect of restricted mealtiming is to shift the temperature acrophase toward the time of the single daily meal. Thus, the subjects' maximum daily temperature occurs earlier under the Breakfast-only condition than under the Dinner-only condition. The acrophase difference between the Breakfast-only and Dinner-only conditions is best seen in Figure 8, where the results for the former are plotted with reference to the acrophase for the latter (i.e., 0° equals acrophase for Dinner-only). Although this difference in shift is statistically significant ($p<0.001$, $F=12.46$, $df=2,16$), the shifts observed under either condition from the *ad libitum* condition are not significant (see Table 26).

The reason for this set of circumstances can be seen in Figure 9. On the right are plotted the group acrophase results with reference to the *ad libitum* mean acrophase and 95% confidence arc. On the left, it is apparent that individual subjects differed greatly in terms of the degree of acrophase shift produced by shifts in mealtiming (see Table 27). The resulting variability contributes greatly to the lack of any large group effect. More important, however, is the suggestion that some individuals can be shifted more than others. The possible role of different *ad libitum* eating patterns in determining the degree of acrophase shift should not be underestimated. It is reasonable to expect that a person who very regularly eats three meals per day would be affected very differently by imposed shifts in mealtiming than would someone who tends to snack all day and rarely eats a large meal. Future analyses of the *ad libitum* eating pattern data should help to shed some light on this speculation. Being able to accurately classify subjects according to their eating patterns before mealtime restriction will produce a clearer picture of how much shifts in mealtiming can affect temperature, as well as other, circadian rhythms.

Unlike oral temperature, pulse showed a dramatic shift in its acrophase following changes in mealtiming (Figure 10). Again, there is little or no difference between the control and experimental subjects under *ad libitum* eating conditions; however, restricted mealtiming significantly shifts ($p<0.001$, $F=35.72$, $df=2,16$) the peak of the pulse rhythm towards the time of eating (see Table 26 also). The presence of this shift among almost all individual subjects is shown in Table 28 along with the extent of shift.

FIGURE 8

CIRCADIAN PHASE RELATIONS AMONG RHYTHMS IN SUBJS ON BREAKFAST OR DINNER ONLY



MEAN COSINOR

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A ORAL TEMP	0.002		19	98	0.35 (0.13 0.59)	-337 (-300 -359)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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FIGURE 9

THERMO ACROPHASE SHIFT AND MEAL-TIMING

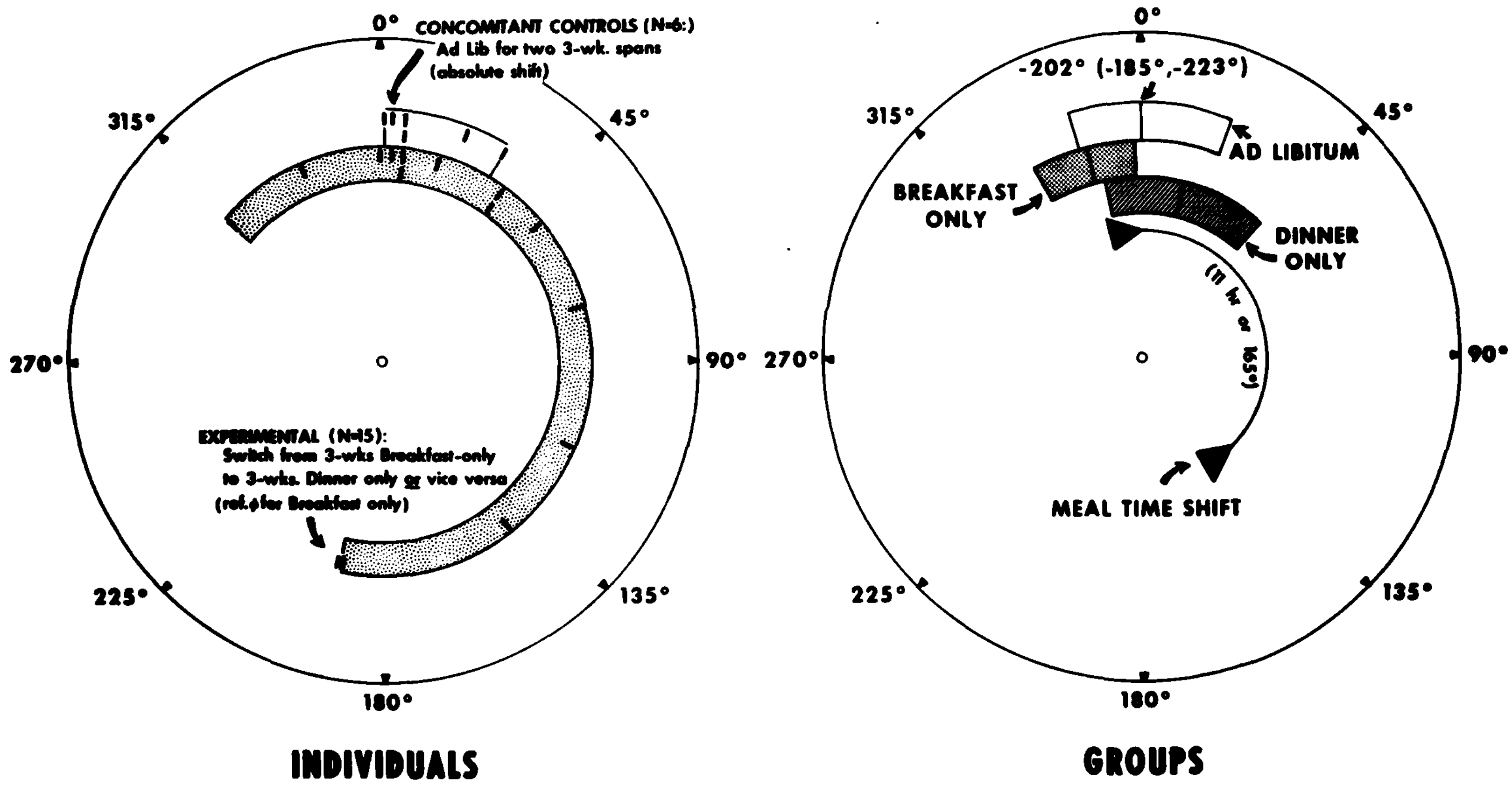


Table 27

IMPUTATIONS BY LEAST SQUARES FIT OF 24—h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

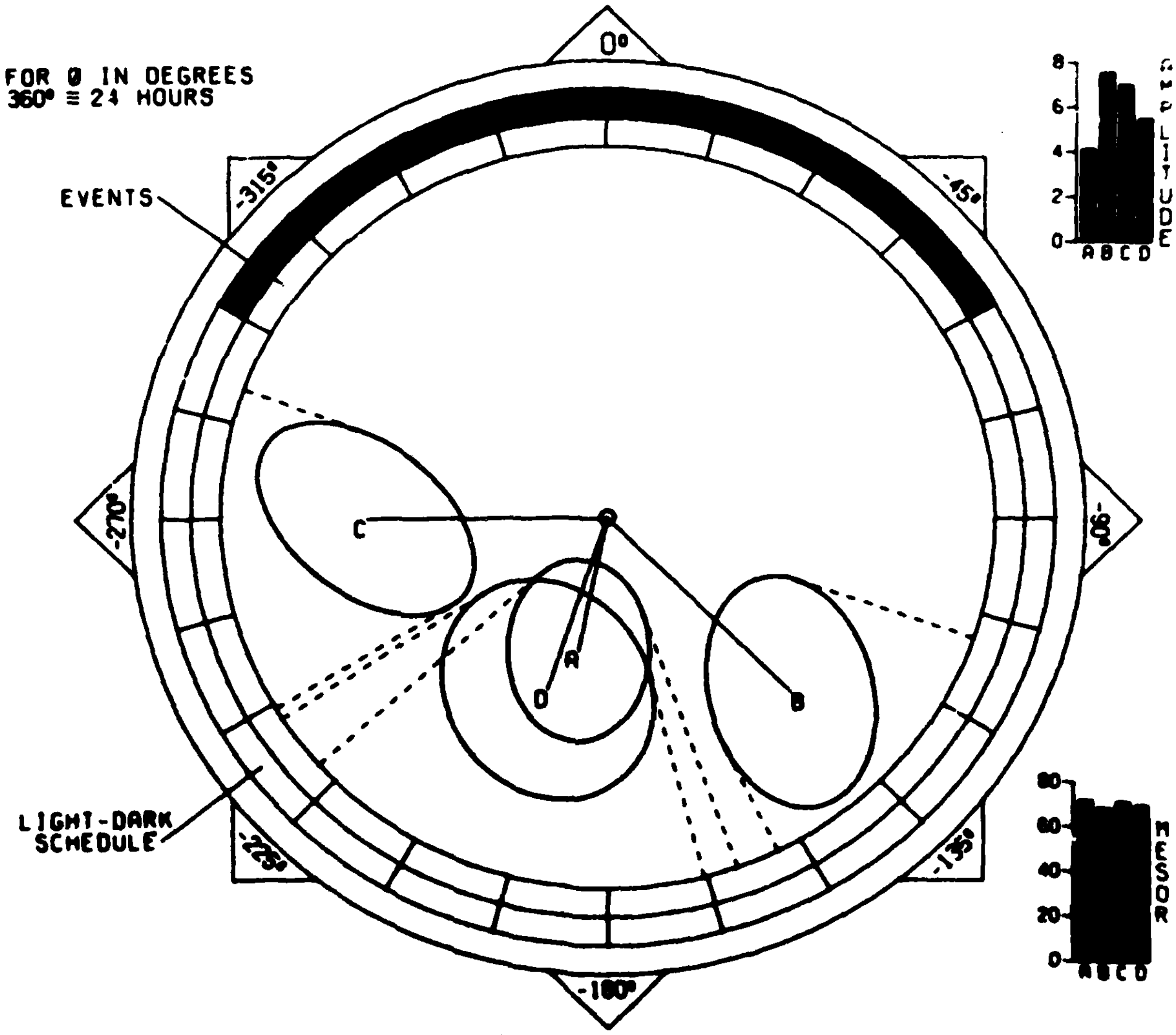
Oral Temperature

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	55*	97.59	0.63	−239	−181	51*	97.66	0.72	−225	−165	− 12	41*	97.60	0.57	−225	−153
2	20*	98.17	0.34	−229	−185	63*	98.11	0.46	−235	−187	−171	<1	98.21	0.01	− 67	− 16
4	42*	97.64	0.43	−272	−222	42*	97.35	0.54	−248	−194	−356	39*	97.53	0.40	−282	−198
5	91*	97.74	0.87	−265	−216	64*	97.66	0.86	−241	−192	−328	84*	97.77	0.68	−273	−224
7	17*	98.07	0.39	−293	−234	17*	97.89	0.30	−186	−159	−216	31*	98.00	0.26	−351	−303
51	79*	97.96	1.05	−280	−191	69*	97.96	0.85	−265	−192	−336	60*	98.02	0.77	−301	−216
53	31*	98.21	0.35	−272	−207	51*	98.27	0.50	−280	−214	−348	31*	98.41	0.42	−294	−226
54	44*	97.95	0.47	−278	−199	49*	98.03	0.51	−237	−169	−263	53*	98.04	0.36	−351	−266
57	35*	98.47	0.35	−344	−270	26*	98.53	0.31	−279	−201	− 2	47*	98.61	0.63	−282	−189
58	35*	98.39	0.49	−269	−214	36*	98.29	0.64	−246	−201	−309	45*	98.19	0.52	−321	−252
59	5	98.17	0.13	−306	−247	13	97.70	0.29	−181	−131	−233	23*	98.12	0.37	−323	−258
61	50*	97.88	0.72	−226	−166	40*	97.67	0.62	−224	−165	−343	13	98.12	0.53	−230	−182
62	40*	98.08	0.49	−247	−189	36*	98.02	0.62	−288	−187	− 10	40*	97.99	0.44	−240	−177
64	47*	98.23	0.39	−242	−200	46*	98.23	0.50	−241	−190	−314	38*	98.24	0.31	−291	−236
66	6	98.83	0.15	− 1	−286	25*	98.49	0.28	−209	−132	−151	11	98.98	0.27	− 42	−341
68	45*	98.25	0.52	−200	−164	47*	98.78	0.46	−221	−188	− 16	8*	98.47	0.22	−199	−172
69	79*	98.46	0.58	−263	−231	46*	98.11	0.47	−249	−217	−339	51*	98.29	0.52	−265	−238
72	21*	98.29	0.50	−253	−207	10	97.90	0.32	−259	−223	−350	29*	97.98	0.57	−295	−233
70						50*	97.83	0.66	−231	−195	−346	44*	98.03	0.42	−234	−209
	Ad Libitum					Ad Libitum						Ad Libitum				
3	28*	97.97	0.53	−225	−184	43*	98.04	0.46	−252	−203		41*	98.06	0.45	−253	−207
6	45*	97.42	0.71	−242	−193	32*	97.68	0.37	−255	−209		49*	97.89	0.37	−276	−220
56	53*	98.29	0.35	−282	−211	59*	98.35	0.32	−281	−216		45*	98.45	0.21	−275	−212
63	11	97.82	0.31	−301	−231	17*	98.00	0.53	−275	−206		27*	97.99	0.70	−307	−226
70	49*	97.81	0.58	−257	−224	54*	97.95	0.55	−244	−215		60*	98.08	0.58	−238	−204
73	—	—	—	—	—	45*	97.90	0.50	−265	−193		60*	97.99	0.49	−262	−200

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroon
Φ = internal acrophase (referred to acrophase of same subject on dinner)
* $P < 0.05$

FIGURE 10

CIRCADIAN RHYTHM IN PULSE OF SUBJECTS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	0.003		18	72	4.1 (1.41 6.9)	-192 (-160 -228)
B BRKFST ONLY	<0.001		19	68	7.5 (4.3 10.9)	-134 (-109 -154)
C DINNER ONLY	<0.001		19	71	7.0 (4.0 10.3)	-270 (-239 -291)
D CONTROLS	0.001		17	70	5.5 (2.35 8.7)	-198 (-165 -237)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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Table 28

IMPUTATIONS BY LEAST SQUARES FIT OF 24—h COSINE FUNCTION
TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

Pulse

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	35*	63.3	3.9	−217	−159	19*	67.4	2.6	−156	− 96	−296	16	64.6	3.9	−232	−160
2	17*	84.9	5.2	−264	−220	14*	76.5	3.9	−190	−142	−180	30*	82.3	6.6	− 13	−322
4	6	67.6	2.0	− 13	−323	37*	64.7	5.0	−136	− 82	−116	5	65.8	1.8	− 14	−326
5	52*	56.7	6.2	−235	−186	61*	58.0	10.8	−191	−142	−292	32*	63.2	3.6	−259	−210
7	2	64.9	1.6	− 75	− 16	63*	57.0	6.3	−126	− 99	−170	59*	58.6	8.1	−337	−289
51	37*	66.7	6.2	−226	−137	29*	62.7	7.9	−201	−128	−275	22*	65.1	7.1	−298	−213
53	34*	70.8	6.4	−263	−198	33*	66.5	11.3	−224	−158	−249	49*	74.8	12.6	−337	−269
54	15	60.0	3.7	−301	−222	39*	61.4	7.4	−178	−110	−171	41*	67.8	9.6	− 24	−299
57	27*	88.5	6.5	−334	−260	4	88.1	2.1	−331	−251	− 35	33*	84.8	8.4	−309	−216
58	4	77.3	2.3	−249	−194	2	75.8	1.7	−200	−155	−235	57*	78.3	7.7	−349	−280
59	4	81.1	1.7	−284	−225	32*	74.0	6.0	−166	−116	−215	40*	81.5	7.1	−326	−261
61	6	67.3	1.9	−265	−205	23*	67.0	4.7	−127	− 68	−224	4	66.6	2.8	−252	−204
62	11	73.6	6.9	−247	−189	21*	69.1	7.7	−245	−144	−258	19*	72.5	4.9	−309	−246
64	7	65.2	3.7	− 79	− 37	4	62.2	2.0	−102	− 51	−115	41*	67.0	8.1	−351	−296
66	11	74.8	3.9	−291	−216	27*	68.7	7.0	−264	−187	−250	8	73.5	3.4	−358	−297
68	32*	85.8	6.4	−191	−155	30*	85.7	3.9	−152	−119	−172	8*	85.3	2.0	−334	−307
69	30*	74.9	5.8	−214	−182	33*	72.9	8.3	−185	−153	−248	20*	77.9	3.6	−292	−265
72	20*	70.3	3.5	−247	−201	25*	66.0	5.5	−189	−153	−234	57*	65.5	7.8	−341	−279
70						19*	53.2	7.0	−196	−160	−234	37*	57.7	7.9	−311	−286
	Ad Libitum					Ad Libitum						Ad Libitum				
3	27*	66.2	6.3	−277	−236	16*	68.6	4.2	−276	−227		25*	69.0	5.6	−251	−206
6	31*	79.3	5.9	−205	−156	9	80.5	2.1	−157	−111		17*	81.2	3.5	−240	−184
56	3	76.0	2.6	− 52	−341	2	72.1	1.7	− 79	− 14		5	73.3	1.6	−111	− 48
63	43*	64.3	10.2	−240	−170	20*	70.1	8.7	−222	−153		9	71.7	5.5	−256	−174
70	33*	50.6	5.4	−284	−251	18*	56.1	4.5	−254	−225		37*	61.4	6.6	−277	−243
73						18*	69.3	6.1	−260	−188		51*	72.6	7.5	−257	−195

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P < 0.05

The results for diastolic and systolic blood pressure shown in Table 26 suggest that the former is more affected by mealtiming changes than the latter. As Figure 11 indicates, the group rhythm for diastolic blood pressure was shifted away from the time of the single daily meal ($p<0.002$, $F=9.76$, $df=2,16$), unlike the direction of shift produced for pulse. Individual results are presented in Table 29. The group rhythms for systolic blood pressure did not show any shift following shifts in mealtiming, but this lack of shift is secondary to the fact that the Dinner-only group did not demonstrate a statistically significant rhythm while the Breakfast-only group barely did so (Figure 12). Again, future regrouping of the individual rhythms shown in Table 30 on the basis of **ad libitum** eating patterns may shed some light on the apparent lack of a mealtiming effect.

The relationship among the effects of mealtiming on pulse and blood pressure are dramatically apparent when a single subject's rhythms are plotted on a chronogram (see Glossary). Figures 13 through 15 depict the daily cosinor results for Subject No. 51's pulse, diastolic blood pressure, and systolic blood pressure over a 10-week span. The numerals 1, 2, 3, and 4 along the abscissa indicate the beginnings and ends of Stages IV, V (Breakfast-only), and VI (Dinner-only) in that order. In comparing the three figures, note the differences in the acrophase shifting during Stages V and VI. There is also a lowering of the mesor (see Glossary) for both systolic and diastolic blood pressure during the restricted mealtime stages and an increase in amplitude for diastolic blood pressure during the Dinner-only condition.

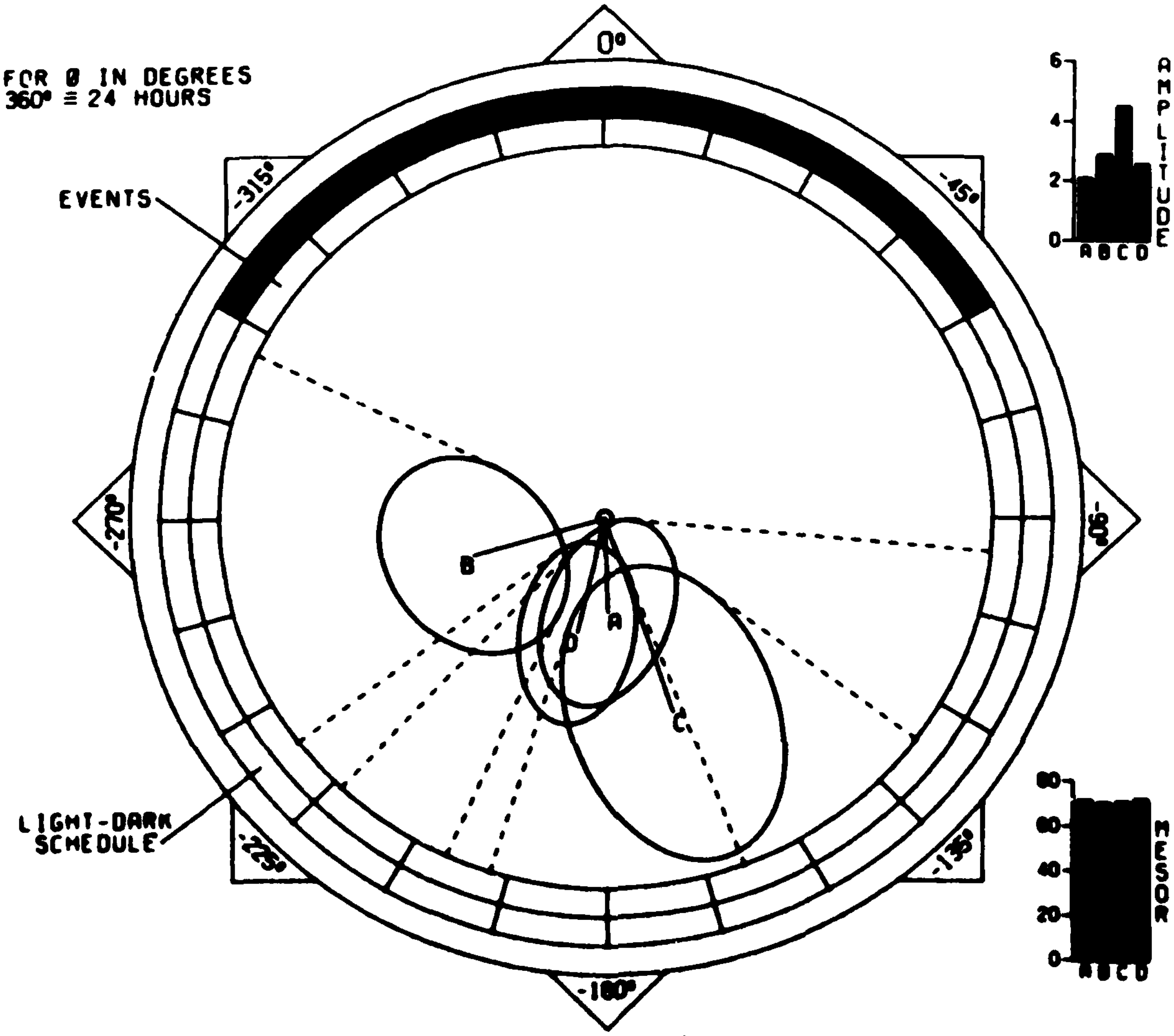
Two other self-measurements, mood and vigor ratings, are included here because they are intended to reflect the person's general psychological and physiological states. As Figures 16 and 17 indicate, however, the acrophases of these rhythms did not shift much as a result of restricted mealtiming. The acrophases were essentially the same for all four conditions in the case of vigor rating, which the error ellipses show was less variable than mood rating. The individual results shown in Table 31 further substantiate the lack of any shift. Despite its greater variability (see Table 32), there is some evidence that the mood acrophase shifted to a slightly later time in the day when subjects ate at restricted mealtimes regardless of the time (Table 26). The acrophase for the Breakfast-only condition differed significantly ($p<0.003$, $F=8.30$, $df=2,16$) from the **ad libitum** acrophase, while the Dinner-only acrophase shift approached statistical significance ($p<0.08$, $F=3.05$, $df=2,16$).

Considering the rather substantial shifts in the more objective physiological indices, it is possible that, although an overall shift in physiological rhythms occurred, subjects were not aware of the induced changes in their ability to perform throughout the day. In this regard, it should prove worthwhile in future analyses to examine the relationship between the extent of a subject's shifts in temperature, pulse, and blood pressure with the degree of perceived shift in vigor and mood.

Figure 18 summarizes the results for this set of self-measurements, except for temperature, by comparing the acrophases on Breakfast-only relative to those for

FIGURE 11

CIRCADIAN RHYTHM IN DIAST BP OF SUBJECTS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	0.033		18	72	2.09 (0.15 4.1)	-178 (-95 -224)
B BRKFST ONLY	0.003		19	70	2.89 (1.01 4.8)	-254 (-205 -296)
C DINNER ONLY	0.007		19	71	4.5 (1.19 7.8)	-161 (-126 -198)
D CONTROLS	0.011		17	72	2.58 (0.57 4.6)	-193 (-159 -233)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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Table 29

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

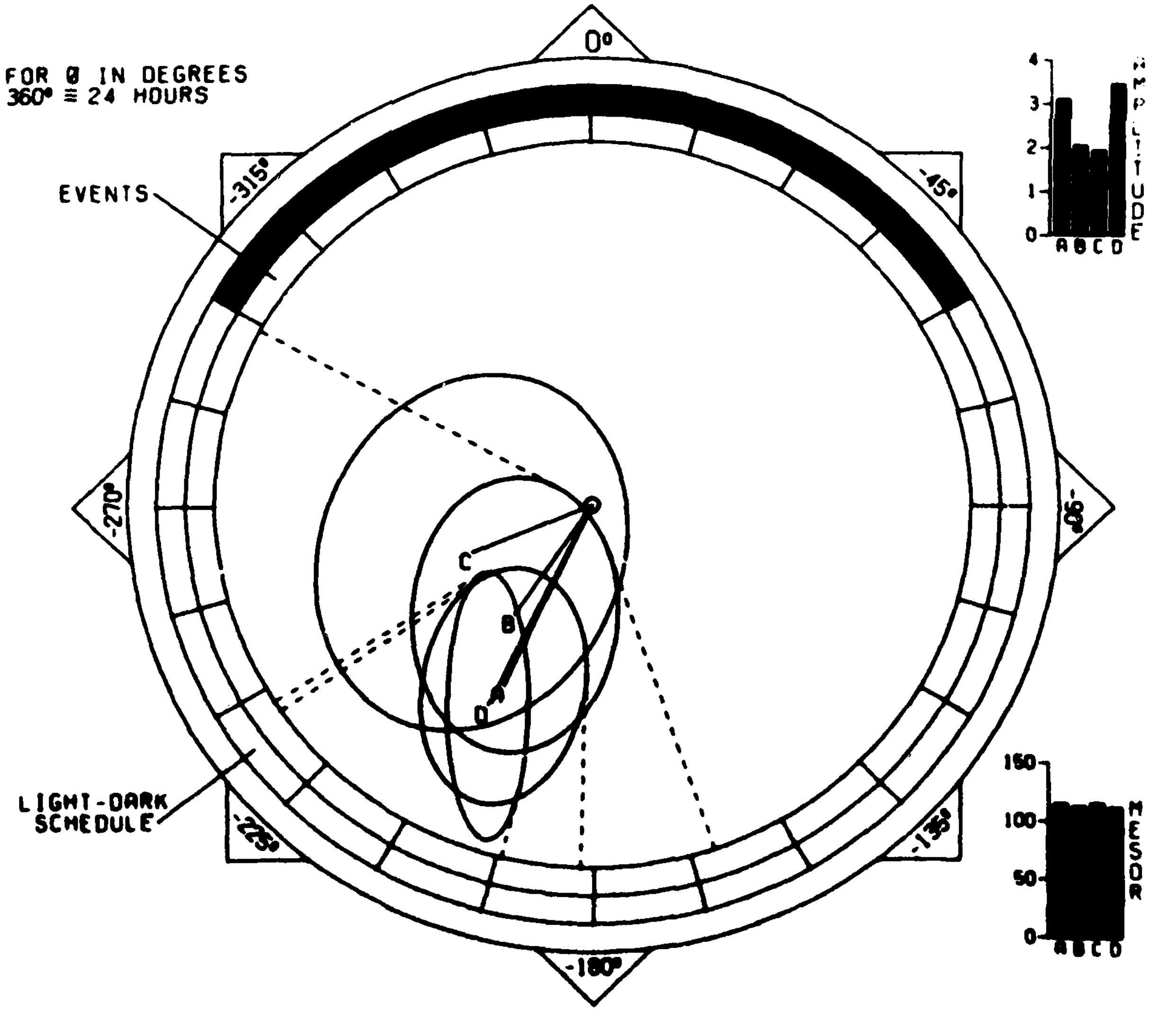
Diastolic Blood Pressure

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	5	72.7	1.7	−121	− 63	12	72.6	3.5	−239	−179	− 18	18*	73.0	4.2	−233	−161
2	13	74.4	1.6	−156	−112	16*	72.3	1.9	−154	−106	−344	32*	72.2	3.1	−173	−122
4	6	75.5	1.1	− 94	− 44	1	69.5	.8	−219	−165	−146	10	73.2	1.8	− 67	− 19
5	31*	64.9	3.9	−235	−186	47*	62.2	4.6	−228	−179	−353	59*	63.9	5.5	−235	−186
7	1	68.8	.9	−221	−162	25*	66.5	4.1	−297	−270	−260	5	68.2	3.0	− 58	− 10
51	2	75.1	1.2	−249	−160	26*	73.5	3.8	− 12	−299	−173	52*	71.9	7.0	−211	−126
53	8	77.4	1.5	−304	−239	11	77.5	2.2	−324	−258	− 36	21	80.3	2.1	−290	−222
54	4	59.9	2.5	−221	−142	26*	53.4	4.1	−340	−272	− 65	27*	58.8	4.9	−292	−207
57	11	82.0	2.5	− 23	−309	2	82.2	1.0	−291	−211	− 28	12	75.8	3.6	−276	−183
58	<1	81.4	.4	−323	−268	5	81.3	2.3	− 12	−327	−359	6	79.1	2.1	− 37	−328
59	11	62.3	4.2	−217	−158	29*	60.6	6.1	−266	−216	− 73	33*	62.9	5.4	−208	−143
61	10	71.6	3.4	−196	−136	32*	71.1	4.5	−275	−216	− 75	12	71.2	3.1	−189	−141
62	2	77.4	2.1	−250	−192	11	73.5	2.5	−233	−132	−344	49*	73.8	7.0	−211	−148
64	<1	71.1	.2	−336	−294	16	69.2	4.2	−315	−264	−314	29*	73.2	3.6	− 5	−310
66	1	59.3	1.0	−134	− 59	28*	65.6	4.6	−355	−278	−122	59*	61.2	9.4	−217	−156
68	24*	71.3	2.4	−269	−233	21*	72.6	1.7	−329	−296	−120	33*	71.7	4.8	−203	−176
69	34*	80.8	9.4	−240	−208	13*	73.0	4.5	−335	−302	−112	41*	77.3	10.3	−217	−190
72	6	61.9	2.6	−235	−189	1	61.4	1.5	− 21	−345	−232	24*	59.4	5.3	−175	−113
70						28*	79.8	4.5	−345	−309	− 90	10	79.4	1.8	−244	−219
	Ad Libitum					Ad Libitum						Ad Libitum				
3	9	75.5	1.6	−261	−220	7	75.6	1.1	−295	−246		2	73.8	.8	−204	−158
6	44*	73.9	6.0	−233	−184	27*	71.1	3.8	−240	−194		45*	73.0	4.7	−267	−211
56	20*	67.8	3.5	−285	−214	14	65.6	3.0	−261	−196		46*	63.8	4.6	−216	−153
63	4	76.1	1.6	−259	−189	9	77.4	1.8	−150	− 81		6	79.3	2.1	−120	− 38
70	5	69.5	1.4	−173	−140	9	73.5	1.3	−283	−254		13	82.4	1.8	− 2	−328
73	–	––	––	––	––	11	64.0	1.7	−323	−251		50*	63.1	3.2	−256	−194

PR = percent rhythm; M = Mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P $P < 0.05$

FIGURE 12

CIRCADIAN RHYTHM IN SYST BP OF SUBJECTS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	115	3.10 (1.31 4.9)	-205 (-182 -236)
B BRKFST ONLY	0.035		19	112	2.05 (0.12 4.1)	-214 (-161 -299)
C DINNER ONLY	0.140		19	115	1.94 ( )	-248 ( )
D CONTROLS	<0.001		17	112	3.5 (1.76 5.4)	-207 (-194 -238)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

CHRONOBIOLOGY LABORATORIES UNIVERSITY OF MINNESOTA
MINNEAPOLIS MINNESOTA 55455 USA PHONE (617) 373-2920

Table 30

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

Systolic Blood Pressure

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	17*	119.5	3.9	−281	−223	18*	122.7	3.2	−276	−216	− 7	27*	118.9	4.7	−281	−209
2	16*	110.2	3.2	−216	−172	23*	112.0	3.2	−186	−138	− 23	29*	106.7	2.9	−166	−115
4	11	117.9	2.7	−236	−186	26*	111.2	4.3	−235	−181	−248	15*	116.6	3.3	−341	−293
5	54*	117.4	9.6	−240	−191	60*	110.7	11.6	−239	−190	−138	3	129.0	16.7	−101	− 52
7	18	121.5	3.5	−324	−265	25*	113.7	7.0	−241	−214	−293	62*	119.8	7.7	−329	−281
51	58*	122.0	6.7	−287	−198	26*	118.9	4.3	−284	−211	−298	19*	121.5	2.7	−358	−273
53	24*	118.5	5.1	−283	−218	28*	120.8	5.6	−357	−291	− 16	39*	122.8	6.2	−343	−275
54	<1	112.3	0.4	−148	− 69	31*	106.6	5.3	− 98	− 30	−108	40*	114.6	5.5	− 7	−282
57	10	106.8	2.7	− 19	−306	18*	105.6	3.5	−320	−240	− 43	6	104.2	3.3	−290	−197
58	3	120.6	2.1	−116	− 61	4	117.3	2.8	− 96	− 51	− 99	51*	114.3	9.3	− 21	−312
59	48*	108.4	7.6	−231	−172	8	105.5	2.1	−201	−151	−290	24*	109.0	4.1	−286	−221
61	13	121.7	6.0	−245	−185	6	122.8	3.0	−297	−238	− 61	7	123.4	3.9	−225	−177
62	2	118.0	1.3	−237	−179	5	112.7	1.9	−250	−149	−339	66*	112.3	6.4	−233	−170
64	44*	124.0	5.8	−309	−267	22*	123.5	4.8	−304	−253	−306	34*	129.2	5.2	− 2	−307
66	2	104.6	2.2	−270	−195	18	100.6	6.6	−276	−201	−261	23*	106.0	5.2	− 1	−300
68	24*	97.7	3.3	−254	−218	7	104.3	1.0	−305	−272	− 54	25*	101.8	3.9	−245	−218
69	45*	119.3	11.1	−250	−218	27*	108.1	6.9	−326	−294	−100	58*	109.6	14.4	−221	−194
72	11	105.2	3.4	−233	−187	22*	101.5	4.6	−179	−143	−309	3	105.9	1.5	−256	−194
70						21*	119.0	2.8	−342	−306	− 25	23*	121.5	3.1	−306	−261
	Ad Libitum					Ad Libitum						Ad Libitum				
3	23*	120.8	4.4	−258	−217	53*	123.3	3.6	−313	−264		15*	128.2	3.2	−306	−259
6	25*	103.6	6.1	−227	−178	20*	100.9	5.3	−245	−199		42*	103.9	6.4	−267	−211
56	48*	98.7	8.0	−259	−188	60*	97.6	7.7	−253	−188		68*	98.3	7.4	−262	−199
63	6	116.1	2.8	−271	−201	9	116.6	4.4	−267	−198		3	124.2	2.6	− 70	−348
70	3	117.6	0.7	−299	−266	19*	120.2	1.9	−294	−265		23*	124.5	2.5	−264	−230
73	—	—	—	—	—	11	106.0	1.7	−323	−251		56*	103.1	4.7	−268	−206

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P < 0.05

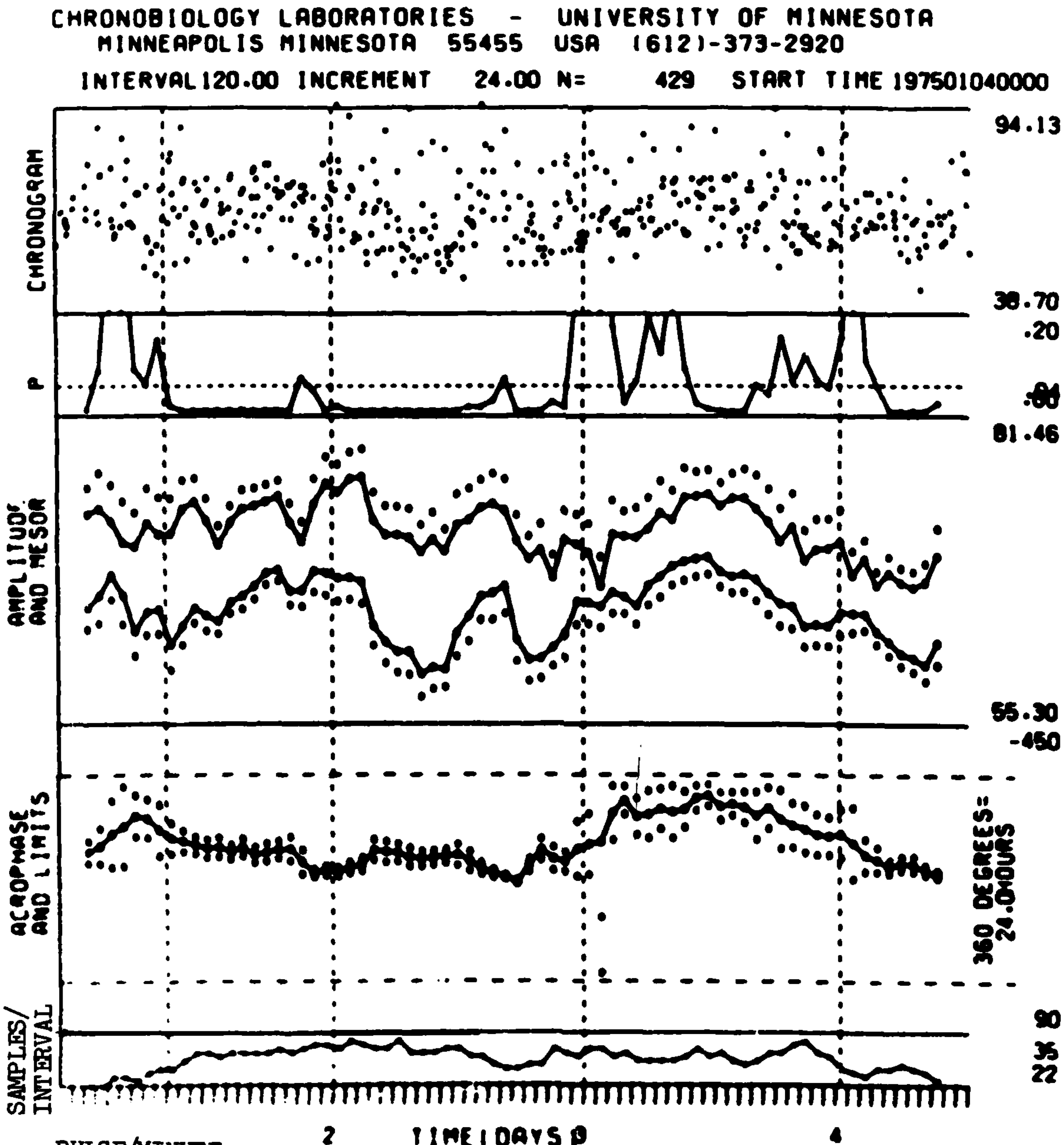
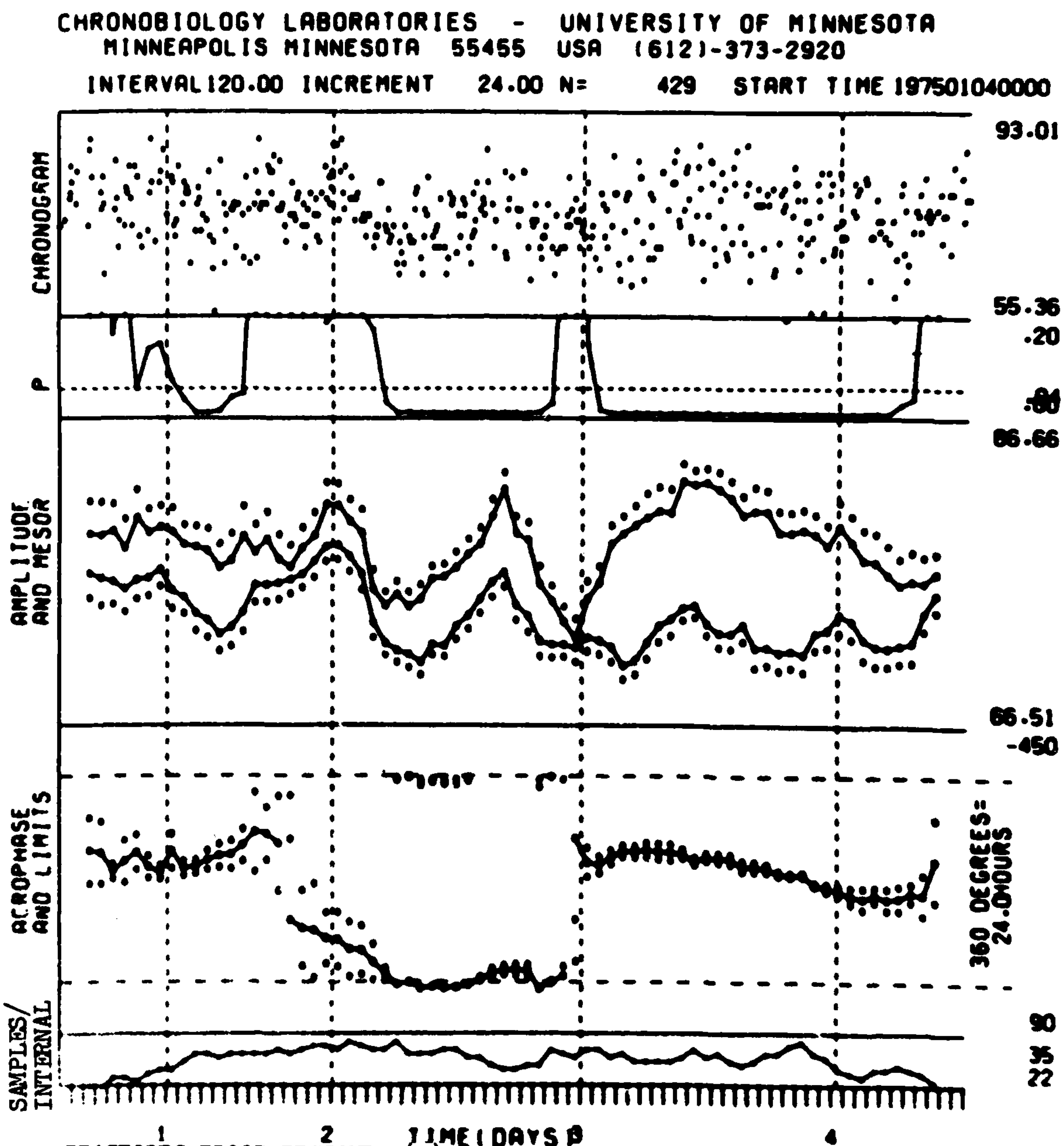


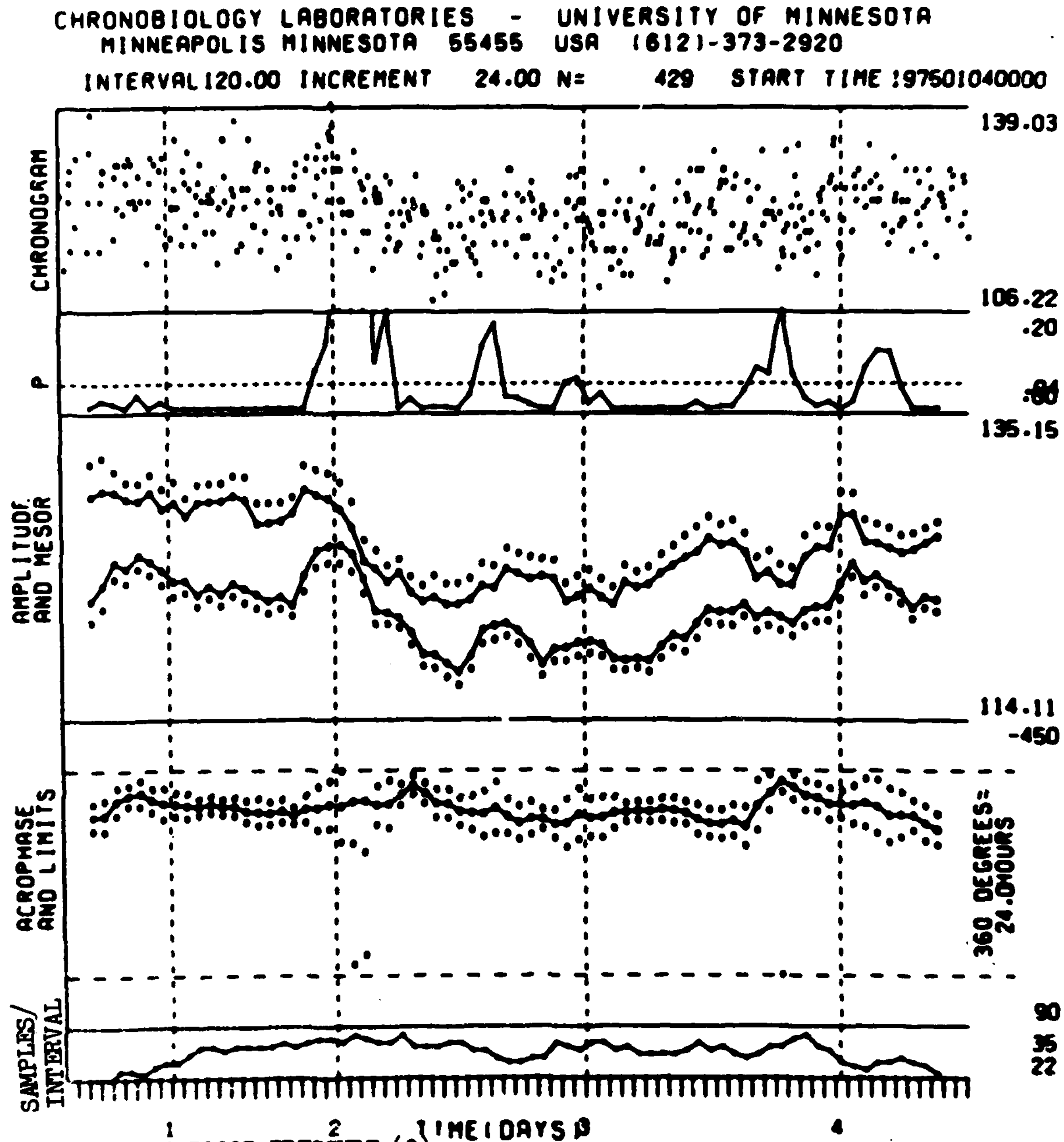
Figure 13. Summary of Subject 51's pulse throughout experiment showing self-measurements (chronogram) and their cosinor analysis. Included are daily variations in the probability (p), mesor, amplitude (upper function), and acrophase of computed circadian rhythm.



DIASTOLIC BLOOD PRESSURE (3)

EFFECT OF MEAL-TIMING ON RHYTHMS (RBS)

Figure 14. Summary of Subject 51's diastolic blood pressure throughout experiment showing self-measurements (chronogram) and their cosinor analysis. Included are daily variations in the probability (p), mesor, amplitude (upper function), and acrophase of computed circadian rhythm

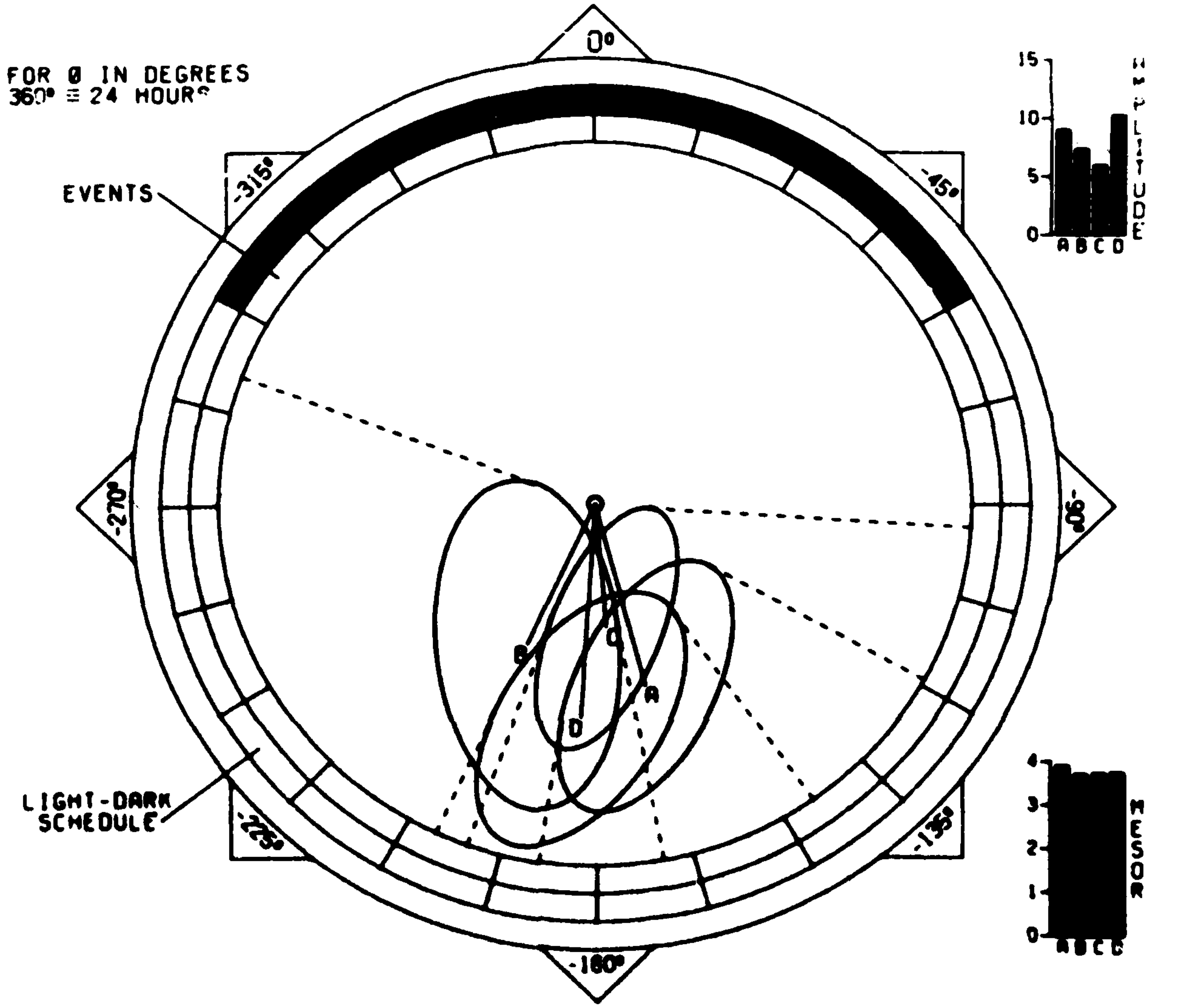


SYSTOLIC BLOOD PRESSURE (3)
EFFECT OF MEAL-TIMING ON RHYTHMS (RBS)

Figure 15. Summary of Subject 51's systolic blood pressure throughout experiment showing self-measurements (chronogram) and their cosinor analysis. Included are daily variations in the probability (p), mesor, amplitude (upper function), and acrophase of computed circadian rhythm.

FIGURE 16

CIRCADIAN RHYTHM IN MOOD RATING OF SUBJS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	3.9	9.0 (4.2 14.8)	-165 (-119 -189)
B BRKFST ONLY	0.019		19	3.7	7.4 (1.00 14.9)	-205 (-169 -291)
C DINNER ONLY	0.007		19	3.7	6.0 (1.21 11.8)	-175 (-93 -200)
D CONTROLS	<0.001		17	3.8	10.3 (4.4 16.7)	-184 (-144 -205)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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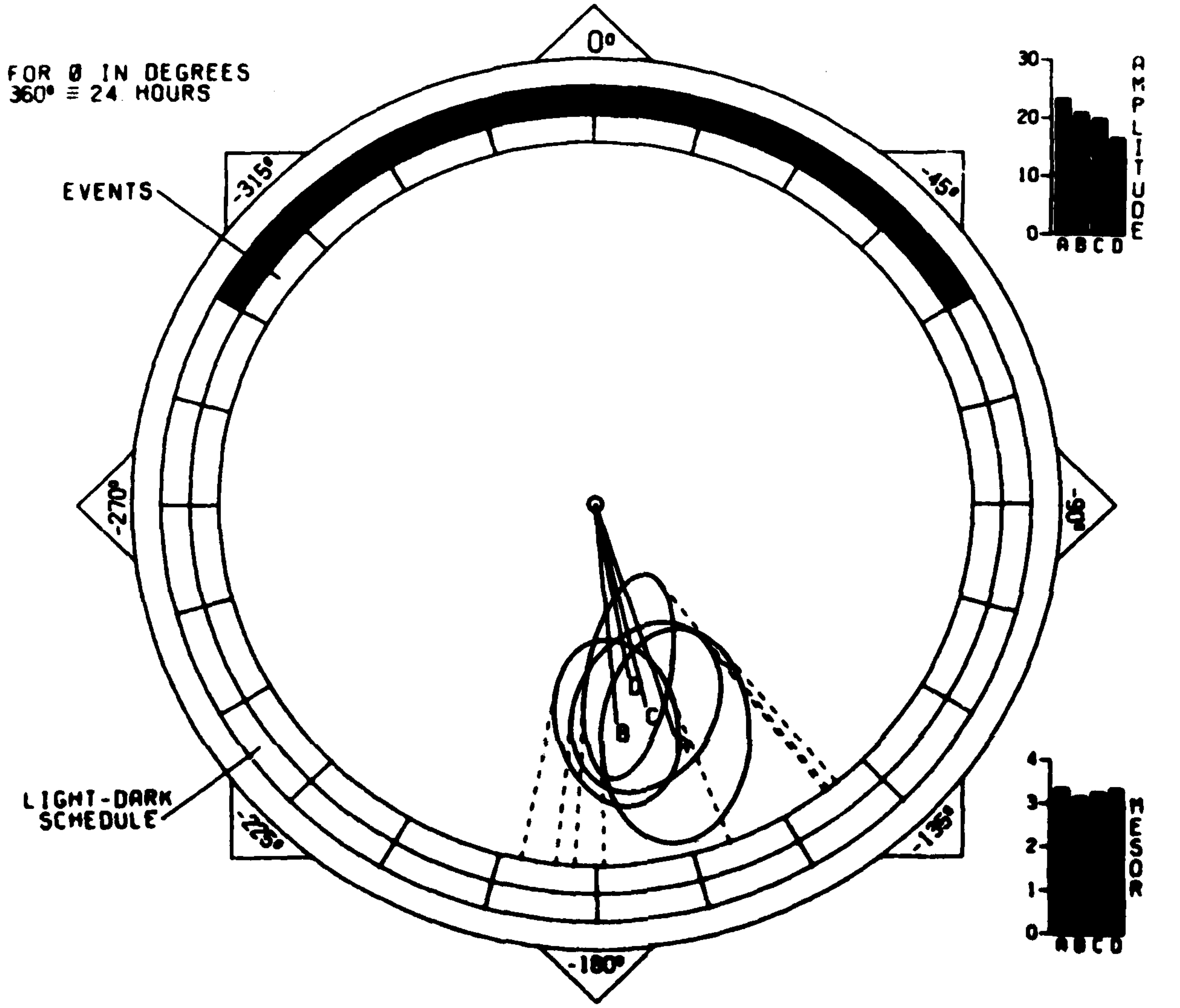
FIGURE 17

CIRCADIAN RHYTHM IN VIGOR OF SUBJECTS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	3.4	23.3 (13.6 33)	-162 (-140 -179)
B BRKFST ONLY	<0.001		19	3.15	20.9 (12.9 28.9)	-175 (-159 -192)
C DINNER ONLY	<0.001		19	3.3	19.9 (12.4 27.6)	-167 (-142 -186)
D CONTROLS	<0.001		17	3.3	16.7 (7.8 26.2)	-169 (-142 -183)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

CHRONOBIOLOGY LABORATORIES UNIVERSITY OF MINNESOTA
MINNEAPOLIS MINNESOTA 55455 USA PHONE (617) 373-2920

Table 31

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

Vigor Rating

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	25*	3.58	0.63	−209	−151	34*	2.62	0.52	−244	−184	− 27	18*	2.87	0.41	−229	−157
2	2	3.53	0.12	−181	−137	57*	4.47	0.61	−228	−180	− 7	63*	4.52	0.62	−224	−173
4	55*	3.66	0.83	−218	−168	37*	3.12	1.00	−232	−178	−360	14*	3.68	0.45	−226	−178
5	82*	4.41	0.77	−229	−180	77*	3.42	0.79	−229	−180	− 2	78*	3.45	0.77	−227	−178
7	3	3.73	0.34	−240	−181	27*	3.62	0.86	−223	−196	− 2	29*	3.56	1.24	−242	−194
51	53*	2.37	1.17	−253	−164	52*	2.21	1.10	−238	−165	−360	51*	2.33	1.25	−250	−165
53	64*	2.57	1.10	−254	−189	37*	2.85	1.25	−238	−172	−328	49*	2.91	1.14	−272	−204
54	49*	3.62	1.59	−233	−154	45*	3.54	1.16	−222	−154	− 1	48*	3.60	1.23	−238	−153
57	22*	2.88	0.83	−283	−209	13	1.79	0.43	−311	−231	− 42	34*	2.34	0.64	−282	−189
58	5	4.33	0.21	−219	−164	13	4.00	0.40	−247	−202	−317	15*	3.84	0.35	−314	−245
59	37*	3.20	1.25	−207	−148	30*	3.07	0.86	−197	−147	− 27	29*	3.15	0.69	−185	−120
61	46*	3.32	0.78	−176	−116	40*	3.22	0.78	−220	−161	− 31	20*	3.59	0.60	−178	−130
62	49*	3.63	0.99	−119	− 61	24*	3.31	0.53	−209	−108	− 15	57*	3.22	0.91	−156	− 93
64	46*	3.43	0.69	−230	−188	32*	3.06	0.67	−251	−200	−354	23*	2.72	0.46	−261	−206
66	29*	3.31	0.85	−244	−169	25*	2.90	0.84	−259	−182	− 29	10	3.31	0.42	−214	−153
68	31*	2.50	0.88	−188	−152	12*	2.68	0.31	−190	−157	−342	37*	2.64	0.60	−202	−175
69	35*	2.89	1.05	−199	−167	24*	2.70	0.63	−233	−201	− 36	15*	2.84	0.89	−192	−165
72	61*	3.43	1.12	−207	−161	28*	3.74	0.34	−223	−187	− 35	25*	3.66	0.48	−214	−152
70						16*	3.60	0.31	−105	− 69	−301	43*	3.55	0.58	−153	−128
	Ad Libitum					Ad Libitum						Ad Libitum				
3	31*	3.67	0.44	−174	−133	29*	3.02	0.61	−176	−127		28*	3.61	0.39	−172	−126
6	30*	3.95	0.56	−240	−191	25*	3.68	0.42	−251	−205		62*	3.52	0.62	−236	−180
56	53*	3.05	1.10	−252	−181	68*	2.97	1.17	−248	−183		73*	3.02	1.42	−250	−187
63	7	3.61	0.40	−213	−143	19*	3.24	0.70	−228	−159		15*	2.93	0.70	−241	−159
70	17*	4.07	0.38	− 16	−343	19*	3.71	0.37	−160	−131		13	3.87	0.29	−175	−141
73	–	––	––	––	––	1	1.94	0.12	−228	−156		27*	2.84	0.79	−244	−182

PR = percent rhythm; M = mesor (rhythm determined average); A = amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P $\leqslant$ 0.05

Table 32

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

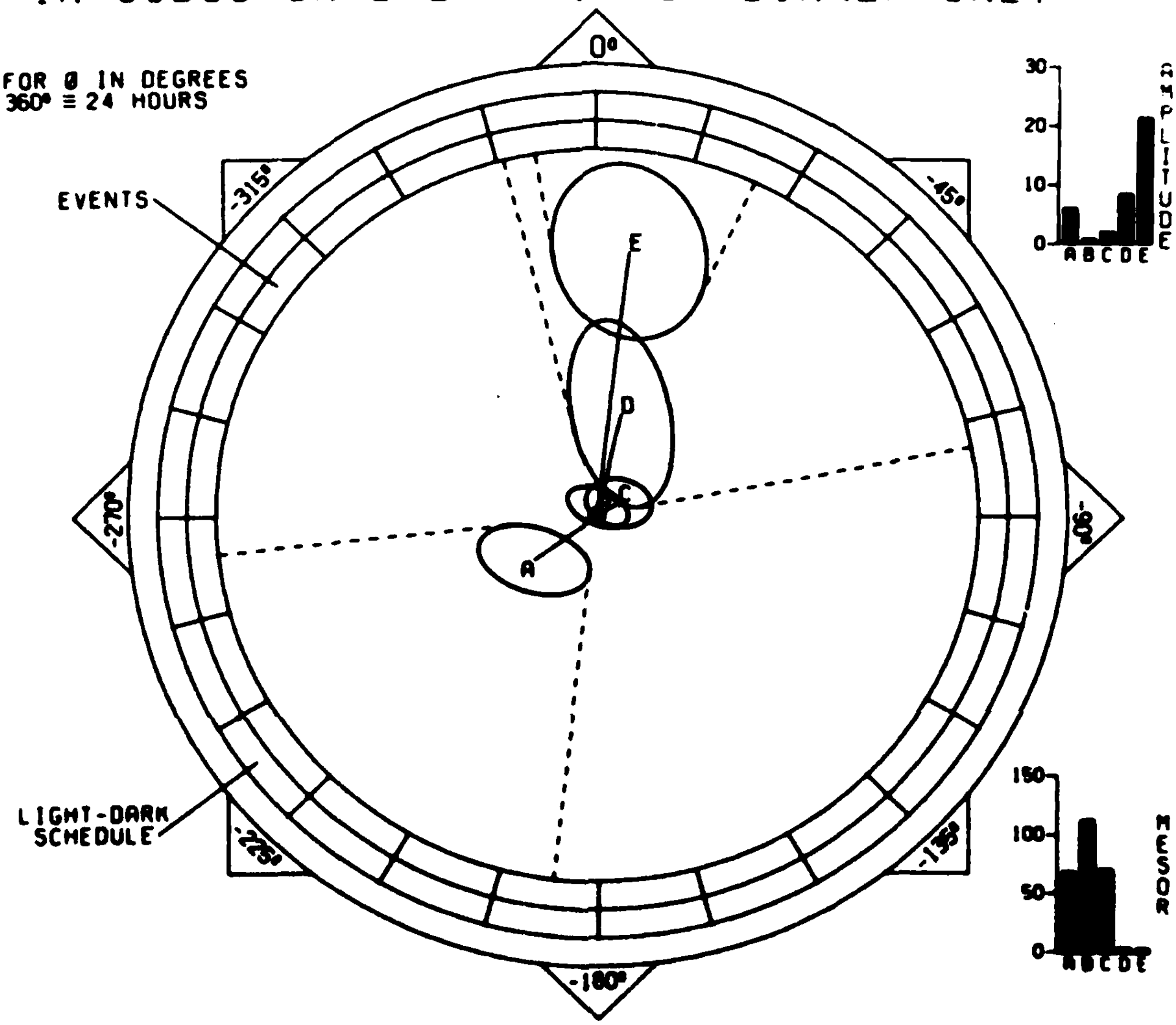
Mood Rating

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	6	3.36	0.31	−204	−146	3	2.78	0.26	− 23	−323	−164	11	2.81	0.42	−231	−159
2	<1	3.54	0.01	−218	−174	27*	4.22	0.37	−214	−166	−335	28*	4.08	0.33	−242	−191
4	58*	3.68	0.88	−217	−167	37*	3.12	1.00	−232	−178	−358	17*	3.82	0.43	−228	−180
5	82*	4.41	0.77	−229	−180	77*	3.42	0.79	−229	−180	− 2	78*	3.45	0.77	−227	−178
7	6	3.89	0.25	−161	−102	17	3.61	0.72	−248	−221	− 16	4	3.81	0.39	−253	−205
51	31*	4.64	0.43	−150	− 61	3	4.10	0.23	− 81	− 8	−336	24*	4.53	0.70	−117	− 32
53	39*	3.11	0.84	−276	−211	35*	3.99	1.18	−266	−200	−345	46*	3.54	1.03	−283	−215
54	23	4.71	0.62	−228	−149	9	4.92	0.26	−162	− 94	−359	6	4.76	0.23	−180	− 95
57	7	3.53	0.40	−210	−136	20*	2.17	0.44	−351	−271	− 97	14	2.67	0.36	−267	−174
58	6	4.34	0.19	−201	−146	4	4.03	0.10	−305	−236	− 42	17*	4.10	0.24	−323	−278
59	3	3.98	0.39	−253	−194	1	4.25	0.15	− 65	− 15	− 39	<1	4.42	0.09	− 41	−336
61	1	3.42	0.20	−242	−182	34*	3.39	0.94	−227	−168	− 2	8	4.03	0.33	−214	−166
62	21*	4.67	0.80	−120	− 62	5	4.59	0.22	−345	−244	−174	6	4.36	0.31	−133	− 70
64	30*	3.69	0.45	−241	−199	7	3.83	0.27	−255	−204	− 64	<1	3.28	0.02	−195	−140
66	24*	3.71	0.67	−262	−187	20	3.58	0.37	−333	−256	− 68	2	3.58	0.19	−249	−188
68	<1	3.99	0.02	−203	−167	6	3.26	0.13	− 95	− 62	− 46	<1	2.69	0.03	− 43	− 16
69	11	3.85	0.26	−197	−165	<1	3.24	0.05	− 2	−330	−159	24*	3.27	0.44	−198	−171
72	37*	3.95	0.87	−212	−166	16*	4.00	0.40	−209	−173	− 29	6	3.86	0.13	−206	−144
70						19	3.97	0.39	−350	−314	−266	3	4.02	0.13	− 73	− 48
	Ad Libitum					Ad Libitum						Ad Libitum				
3	16*	3.88	0.24	−175	−134	19*	3.58	0.34	−160	−111		27*	3.79	0.35	−170	−124
6	33*	3.34	0.59	−241	−192	54*	3.74	0.43	−258	−212		53*	3.73	0.43	−259	−203
56	38*	3.85	0.90	−289	−218	30*	3.79	0.74	−270	−205		30*	3.76	1.21	−256	−193
63	8	4.33	0.30	−283	−213	31*	3.72	0.90	−227	−158		14*	4.17	0.41	−206	−124
70	7	4.30	0.23	− 73	− 43	3	4.19	0.18	−221	−192		3	4.16	0.16	−216	−182
73	–	––	––	––	––	1	2.00	0.11	−201	−129		15	3.01	0.61	−269	−207

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P $\leqslant$ 0.05

FIGURE 18

CIRCADIAN PHASE RELATIONS AMONG RHYTHMS IN SUBJS ON BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A PULSE	<0.001		19	68	6.0 (2.86 9.7)	-234 (-187 -264)
B SYST BP	0.420		19	112	0.75( )	-5 ( )
C DIAST BP	0.084		19	70	1.99( )	-58 ( )
D MOOD	0.008		19	3.7	8.4 (1.84 15.8)	-13 (-346 -79)
E VIGOR	<0.001		19	3.15	21.5 (14.5 28.5)	-7 (-351 -24)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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Dinner-only (i.e., Dinner-only = 0°). The reader is cautioned about the change in the vector scale to accommodate the wide range of amplitudes characteristic of the various circadian rhythms being plotted. This results in the apparent shrinkage of some vectors and ellipses (e.g., diastolic blood pressure) in comparison to earlier polar plots. The advantage of this composite plot is its clear illustration of the substantial advance in pulse on Breakfast-only as compared to the only slight delay in acrophase for the other three statistically significant group rhythms. A similar comparison using Figure 19 also shows that oral temperature advanced slightly during the Breakfast-only condition.

In general, the timing of these physiological rhythms (Figure 19) under *ad libitum* conditions is in good agreement with those reported by others for similar functions in healthy volunteers (Gunther, Knapp, and Halberg, 1969; Kanabrocki, Scheving, Halberg, Brewer, and Bird, 1973).[46,79] The only difference is the slightly later group acrophases for systolic and especially diastolic blood pressure found in the earlier studies. Since differences from 133° to 13° have been described for the acrophase relationship between diastolic and systolic blood pressure (Kanabrocki, et al., 1973),[79] our findings fall into the range of reported variation and are, therefore, not unique. Whether such differences are due to the more variable *ad libitum* eating and sleeping schedules of our subjects compared to those of the other more regimented studies remains to be seen.

Behavioral self-measurements of task performance. The behavioral self-measurement tasks were designed to independently measure circadian variations in eye-hand coordination, manual dexterity, mental processing ability and muscle strength. Although statistically significant group circadian rhythms were documented for each task, there was no significant effect of mealtiming on any of them. Before discussing possible reasons as to why this is true, it is first necessary to review the results.

Figure 20 shows four very distinct, well-defined circadian rhythms for the reciprocal tapping task. The results are presented in terms of a ratio of the number of correct taps over the number of seconds required for completion of the task. Of all the behavioral tasks, this measure of eye-hand coordination produced the greatest indication of a possible shift in acrophase due to altered mealtiming. Possibly, if more subjects had developed significant circadian rhythms (see Table 33), there would have been a greater advance of the acrophase on Dinner-only and a greater delay on Breakfast-only than is shown by the vectors in the cosinor clock.

The finger-counting task is similar to the tapping task in that it can involve eye-hand coordination but differs in that it more directly measures finger and thumb dexterity. Again, very precise rhythms were manifested for the time required to count from one to fifty regardless of the mealtime condition, all with an acrophase of about −190°, (Figure 21). In comparing the individual results for this task (Table 34) with those for tapping (Table 33), it is apparent that most of same subjects exhibited significant rhythms on both tasks. It remains to be seen whether this similarity represents an actual absence of circadian rhythms for coordination in certain individuals or whether it indicates instead

FIGURE 19

DIFFERENT EFFECTS OF MEAL-SCHEDULING ON HUMAN CIRCADIAN RHYTHMS

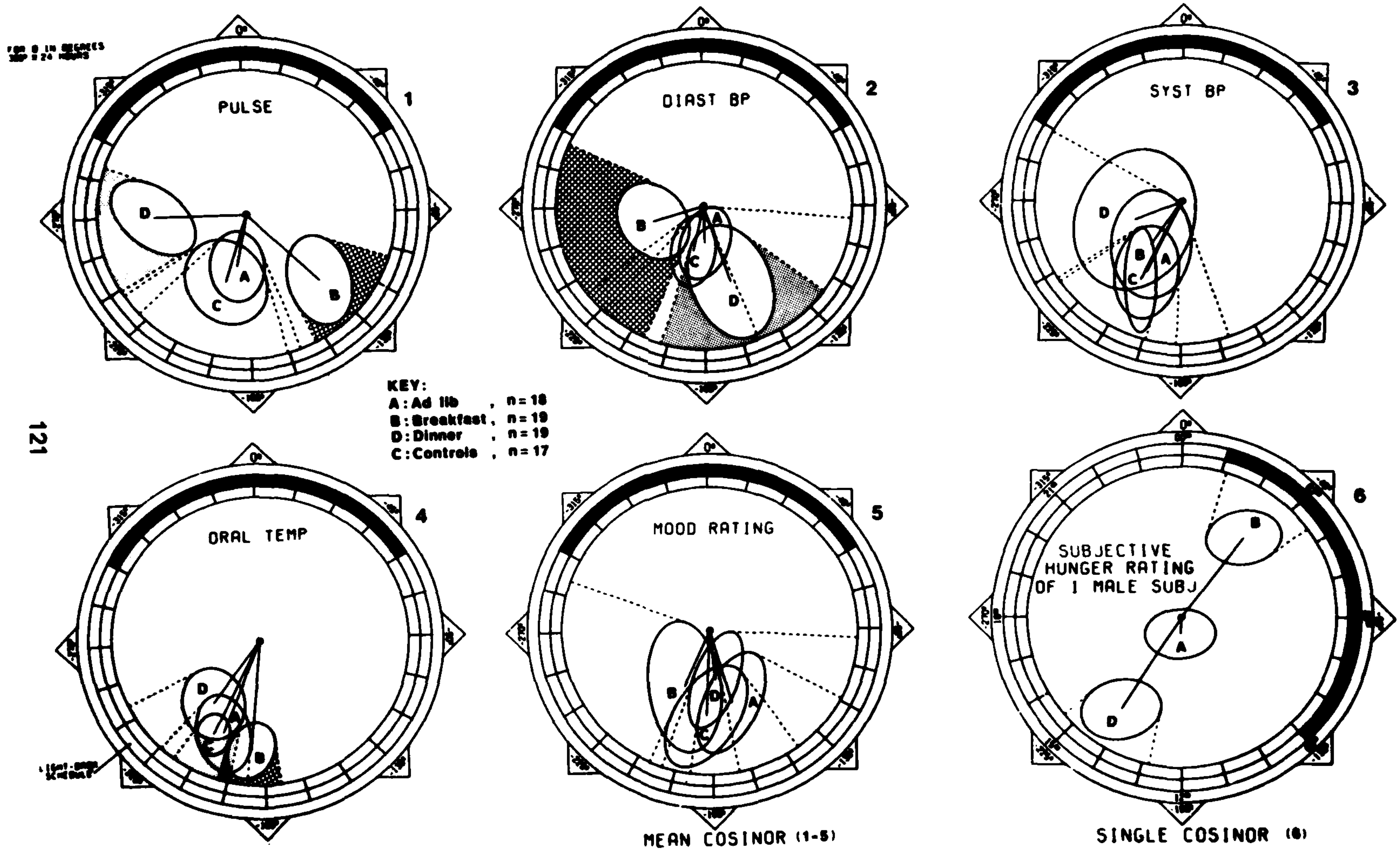
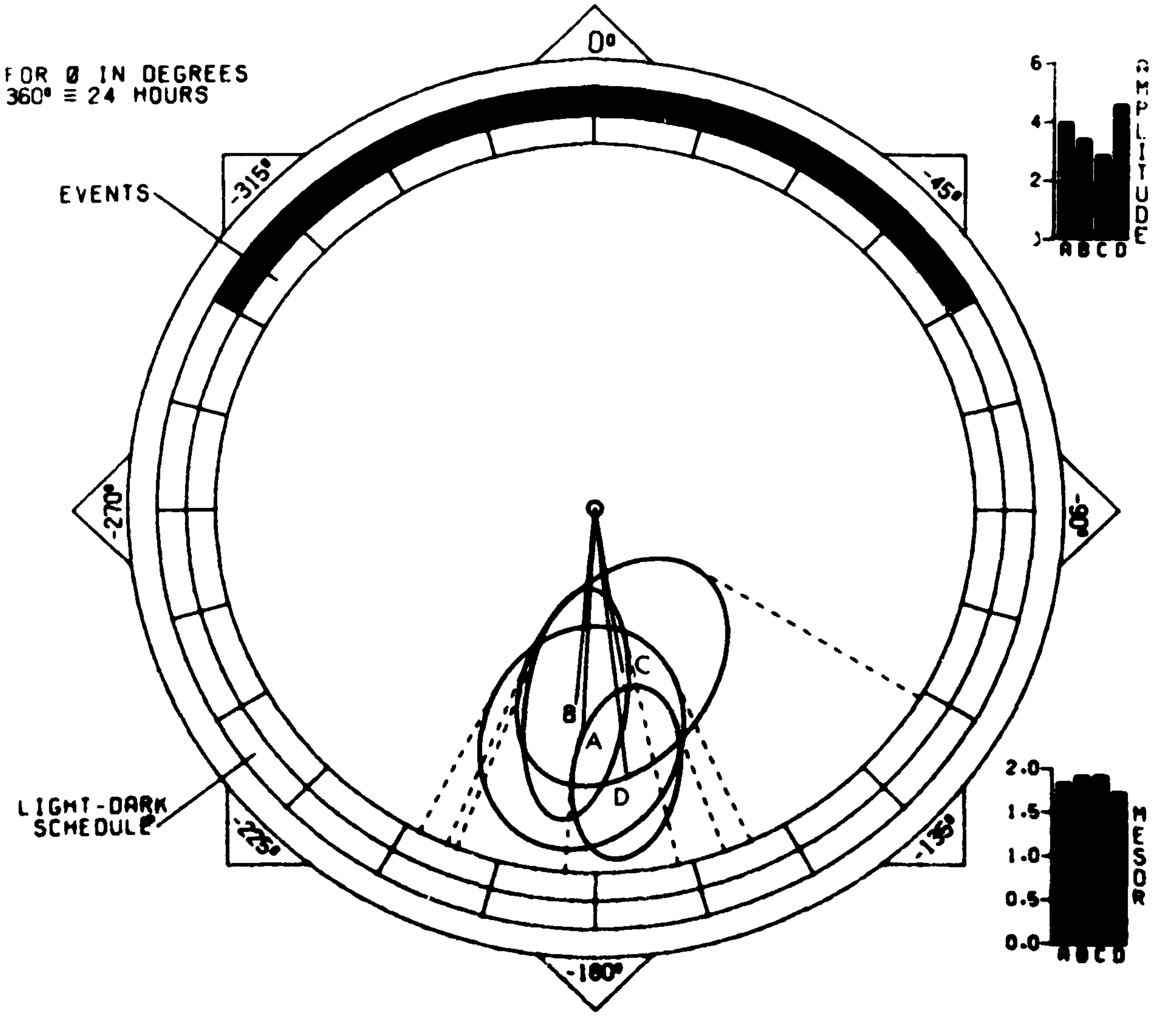


FIGURE 20

CIRCADIAN RHYTHM IN TAPPING RATE OF SUBJ RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	1.83	4.0 (2.03 5.9)	-183 (-156 -208)
B BRKFST ONLY	0.001		19	1.91	3.4 (1.38 5.4)	-185 (-156 -202)
C DINNER ONLY	0.002		19	1.91	2.86 (1.07 4.8)	-171 (-121 -203)
D CONTROLS	<0.001		17	1.72	4.6 (3.13 6.1)	-173 (-160 -185)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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Table 33

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

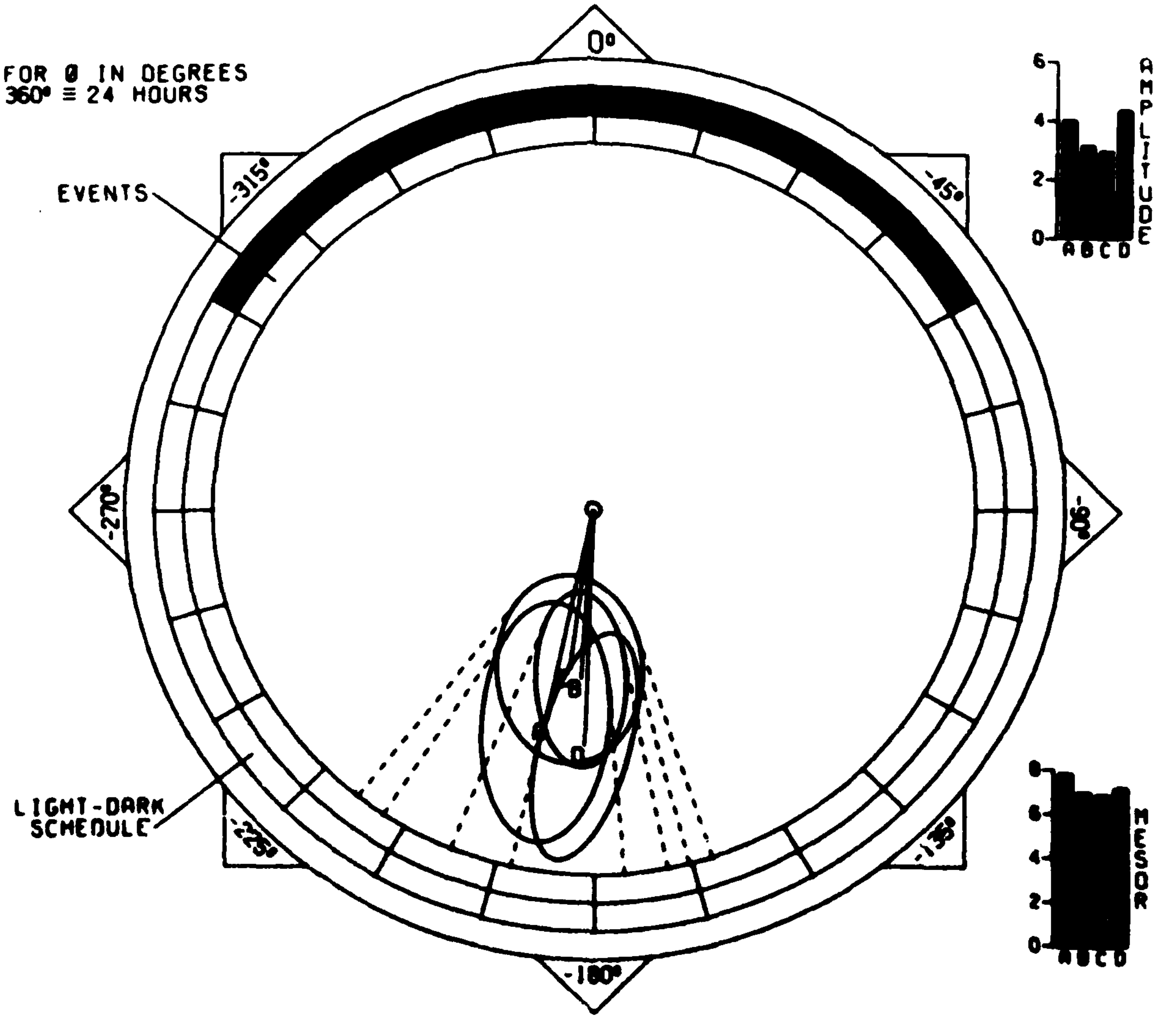
Performance: Tapping Ratio

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	28*	1.80	0.10	–213	–155	22*	1.85	0.07	–223	–163	–201	1	1.84	0.02	– 34	–322
2	12	1.64	0.03	–201	–157	10	1.67	0.03	–239	–191	– 47	8	1.71	0.02	–195	–144
4	37*	2.13	0.21	–248	–198	52*	2.20	0.24	–240	–186	–339	15*	2.22	0.14	–255	–207
5	43*	1.72	0.15	–234	–185	36*	1.86	0.10	–223	–174	–347	54*	1.78	0.16	–236	–187
7	6	1.91	0.04	– 69	– 10	3	2.08	0.02	–193	–166	–130	13	2.18	0.10	– 84	– 36
51	54*	2.02	0.14	–271	–182	51*	2.06	0.13	–261	–188	– 4	35*	2.14	0.10	–269	–184
53	46*	2.04	0.10	–241	–176	9	2.18	0.06	–235	–169	– 4	37*	2.07	0.12	–233	–165
54	5	2.03	0.06	–296	–217	1	2.13	0.03	– 56	–348	–200	6	2.12	0.05	–233	–148
57	24*	1.56	0.11	–213	–139	4	1.65	0.03	–221	–141	–327	8	1.60	0.07	–267	–174
58	7	1.62	0.03	–208	–153	2	1.62	0.03	– 28	–343	–208	3	1.69	0.03	–204	–135
59	7	1.64	0.03	–235	–176	2	1.63	0.01	–148	– 98	–246	9	1.68	0.02	–277	–212
61	3	2.12	0.03	–209	–149	33*	2.03	0.14	–257	–202	– 24	29*	2.05	0.10	–226	–178
62	19*	1.93	0.12	–216	–158	7	1.85	0.10	–301	–200	–130	37*	1.82	0.14	–133	– 70
64	31*	1.63	0.16	–231	–189	23*	1.72	0.14	–225	–174	– 12	40*	1.80	0.18	–217	–162
66	9	1.96	0.05	–251	–176	6	2.08	0.03	–211	–134	–345	15*	2.12	0.05	–210	–149
68	37*	1.70	0.08	–198	–162	30*	1.83	0.06	–204	–171	–354	40*	1.79	0.08	–204	–177
69	20*	1.66	0.07	–278	–246	22*	1.71	0.06	–245	–213	– 30	10	1.71	0.05	–210	–183
72	3	1.78	0.07	–232	–186	25*	1.98	0.09	–217	–181	–351	9	2.00	0.05	–252	–190
70						46*	2.09	0.10	–201	–165	– 6	38*	2.02	0.09	–184	–159
	Ad Libitum					Ad Libitum						Ad Libitum				
3	23*	1.76	0.06	–209	–168	20*	1.74	0.06	–199	–150		13	1.84	0.06	–213	–167
6	40*	1.77	0.14	–216	–167	21*	1.77	0.11	–206	–160		39*	1.85	0.16	–227	–171
56	58*	1.48	0.12	–263	–192	42*	1.55	0.11	–262	–197		33*	1.57	0.10	–250	–197
63	10	1.41	0.05	–225	–155	<1	1.46	0.01	–263	–194		21*	1.52	0.07	–240	–158
70	23*	1.88	0.08	–212	–179	26*	1.96	0.07	–184	–155		36*	1.98	0.09	–198	–164
73	–	––	––	––	––	13	1.86	0.05	–258	–186		11	1.89	0.05	–230	–168

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P $\leq$ 0.05

FIGURE 21

CIRCADIAN RHYTHM IN FINGER COUNTING/SUBJ RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		17	7.8	4.0 (1.82 6.2)	-192 (-175 -214)
B BRKFST ONLY	<0.001		18	7.0	3.13 (1.53 4.7)	-184 (-169 -202)
C DINNER ONLY	0.001		18	6.9	2.97 (1.25 4.7)	-188 (-162 -218)
D CONTROLS	<0.001		17	7.2	4.4 (2.28 6.5)	-182 (-165 -193)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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Table 34

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

Performance: Finger counting

Subj.	Ad Libitum PR	M	A	ϕ	φ	Breakfast PR	M	A	ϕ	φ	Φ	Dinner PR	M	A	ϕ	φ
1	15	13.11	0.68	– 52	–174	3	10.76	0.23	– 46	–166	– 49	8	11.57	0.40	– 9	–117
2	12	5.17	0.11	– 39	–175	5	5.03	0.08	– 40	–172	– 25	32*	4.88	0.13	– 18	–147
4	58*	5.45	0.61	– 61	–191	39*	5.23	0.42	– 60	–186	–348	15*	5.44	0.35	– 66	–198
5	–	—	—	—	—	–	—	—	—	—	—	–	—	—	—	—
7	22	4.90	0.18	–170	–111	1	4.25	0.03	– 40	–193	–237	29*	3.82	0.19	–184	–136
51	36*	6.34	0.40	–106	–197	37*	6.30	0.45	– 74	–181	– 2	54*	5.96	0.42	– 84	–179
53	54*	7.66	0.79	– 85	–200	22*	6.20	0.31	– 76	–190	– 2	28*	6.78	0.33	– 76	–188
54	25*	8.06	0.48	– 75	–176	3	6.87	0.16	– 21	–133	– 14	4	6.57	0.10	– 24	–119
57	7	4.51	0.11	– 78	–184	7	3.86	0.13	–208	–308	–136	1	4.24	0.05	– 85	–172
58	1	5.01	0.07	–107	–232	2	4.92	0.08	– 67	–202	– 64	<1	4.73	0.01	– 27	–138
59	2	10.85	0.15	– 99	–220	8	10.67	0.27	– 45	–175	–320	13	10.06	0.25	–100	–215
61	9	5.70	0.15	– 15	–135	8	5.75	0.23	– 68	–189	– 34	19*	5.77	0.25	– 23	–155
62	12	7.71	0.38	– 57	–179	12	5.35	0.22	– 85	–164	–288	20*	5.42	0.28	–119	–236
64	37*	6.58	0.36	– 95	–223	28*	6.02	0.36	– 53	–182	–320	13	6.30	0.22	– 97	–222
66	1	6.64	0.18	– 75	–180	19	6.02	0.22	– 45	–148	–303	10	6.25	0.25	– 86	–205
68	34*	12.36	0.85	– 24	–168	31*	10.39	0.52	– 60	–207	– 24	12*	11.35	0.74	– 30	–183
69	5	14.66	0.39	– 75	–223	22*	13.26	0.54	– 44	–192	– 23	17*	13.49	0.64	– 16	–169
72	2	8.68	0.13	– 60	–194	5	8.67	0.20	– 74	–218	– 17	28*	5.42	0.31	– 83	–201
70						6	5.81	0.08	–358	–322	– 19	12	5.90	0.11	–328	–303
	Ad Libitum					**Ad Libitum**						**Ad Libitum**				
3	25*	11.45	0.48	– 44	–183	23*	11.07	0.37	– 54	–185		13	10.01	0.27	– 42	–176
6	59*	5.86	0.61	– 56	–187	49*	5.44	0.52	– 57	–191		49*	5.26	0.47	– 60	–184
56	44*	3.97	0.20	– 94	–203	46*	3.93	0.21	– 97	–212		63*	3.96	0.24	– 74	–191
63	16*	10.10	0.64	– 69	–179	1	6.24	0.06	– 64	–175		21*	6.23	0.26	– 67	–165
70	13	8.29	0.20	– 8	–155	7	7.29	0.19	– 8	–159		17*	6.27	0.20	–339	–125
73	–	—	—	—	—	8	8.53	0.34	– 48	–156		1	8.30	0.11	–234	–352

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P < 0.05

some common instructional set or attention deficit. There is no consistent difference between these subjects and the others in terms of the average speed (i.e., mesor) or amplitude of task performance which might suggest an explanation.

Variations in mental processing ability were assessed by the random number addition task. Although Figure 22 suggests that at least the Dinner-only acrophase may differ from that manifested during *ad libitum* eating, there is no statistical evidence to support such a claim ($p<0.11$, $F=2.59$, $df=2, 15$). Here the lack of a mealtiming effect may be traced to the absence of significant circadian rhythms among many individuals (see Table 35).

The final set of behavioral performance tasks measured grip strength in both hands. These results are plotted in Figures 23 and 24 with the individual data provided in Tables 36 and 37. The findings for these tasks mimic fairly well those for the other behavioral self-measurements. The acrophases for the rhythms under the restricted and unrestricted mealtime conditions appear to coincide. The only possible exception is right-hand grip strength under the Breakfast-only condition. The delay in the peak of this rhythm (Figure 24) approaches statistical significance ($0.05<p<0.07$, $F=3.32$, $df=2, 16$) when compared to the *ad libitum* results. Also, more individuals exhibited significant rhythms on the grip-strength task than on the other behavioral tasks. This difference may be due to the greater objectivity provided by the dynamometer in this task compared to the methods used to self-measure other types of performance.

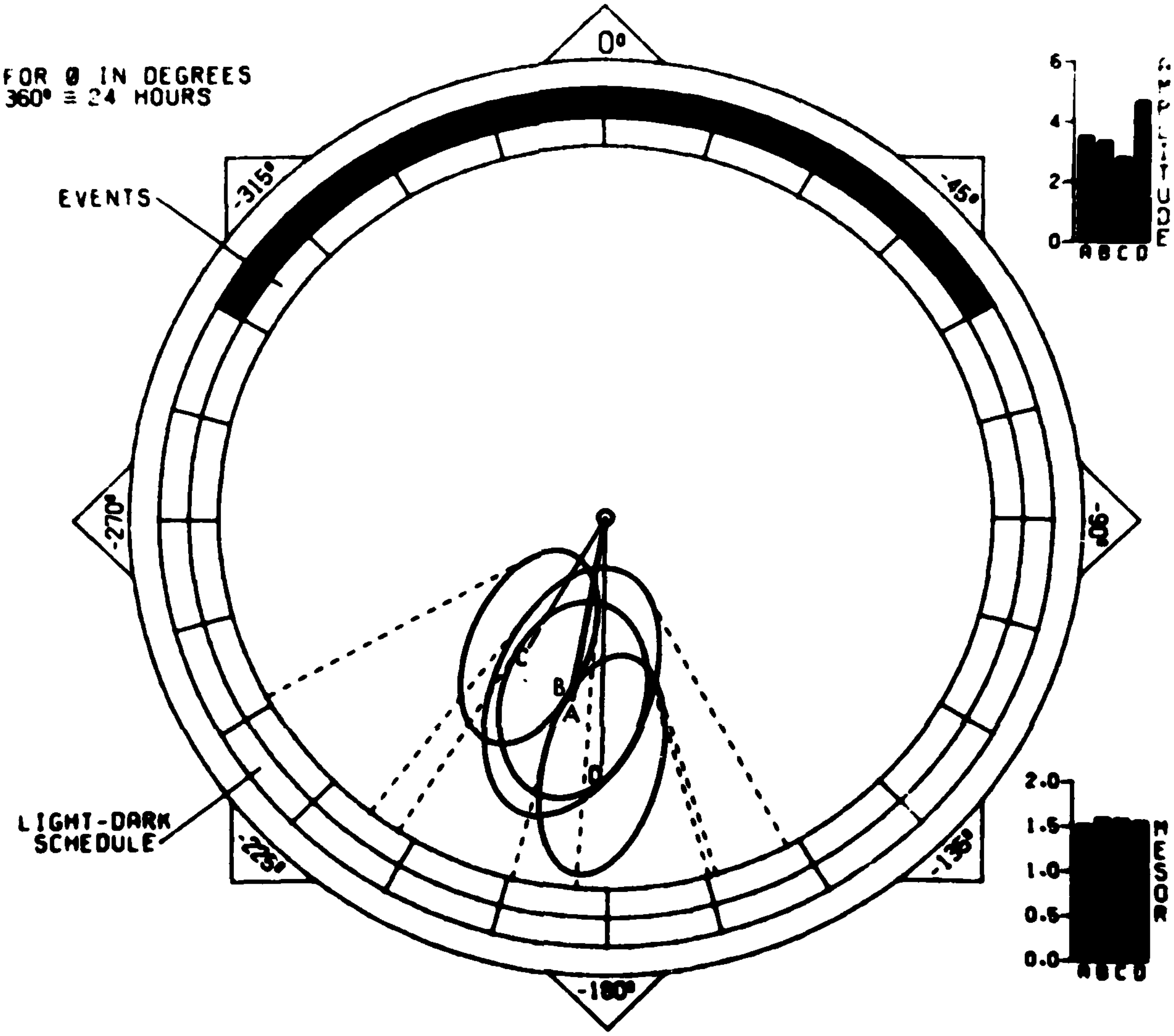
Figure 25 resembles Figure 18 in that it depicts the results for the behavioral self-measurements under the Breakfast-only condition with reference to those for Dinner-only (i.e., 0°). The lack of any substantial differences among the timing of the rhythms under the two restricted mealtime conditions is readily apparent. The polar plots in Figure 26 permit comparision of the results for all performance tasks plus the vigor rating. Despite the absence of any substantial mealtiming effects, the timing of these rhythms corresponds well with those reported previously (Gunther, et al., 1969; Kanabrocki, et al., 1973)[46,79] for presumably healthy subjects (see Appendix F–1 for a mean cosinor summary of the *ad libitum* results).

We have already described shifts in the circadian acrophases for vital signs and, in the next section, will present similar evidence for shifts in the circadian rhythms of certain blood constituents. In view of the effects at mealtiming on internal circadian rhythms, it is surprising that the timing of the task performance rhythms remained unaltered in this experiment. Similar studies on rhythms of performance have demonstrated a strong relationship between levels of behavioral functioning and underlying physiological rhythmicities (e.g., Klein, et al., 1976).[81] The most reasonable explanation of our negative results is that the tasks used here were not demanding enough to be affected by the mealtime-induced changes in bodily functioning.

The necessity of using autorhythmometry to gather circadian performance data required the use of simple, quick, self-paced behavioral tasks which could be

FIGURE 22

CIRCADIAN RHYTHM IN ADD SPEED OF SUBJS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	1.52	3.5 (1.62 5.4)	-190 (-164 -213)
B BRKFST ONLY	0.006		19	1.59	3.4 (0.94 5.8)	-191 (-152 -218)
C DINNER ONLY	0.004		19	1.58	2.82 (0.90 4.8)	-210 (-185 -241)
D CONTROLS	<0.001		17	1.56	4.7 (2.62 6.8)	-181 (-163 -194)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
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Table 35

IMPUTATIONS BY LEAST SQUARES FIT OF 24—h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

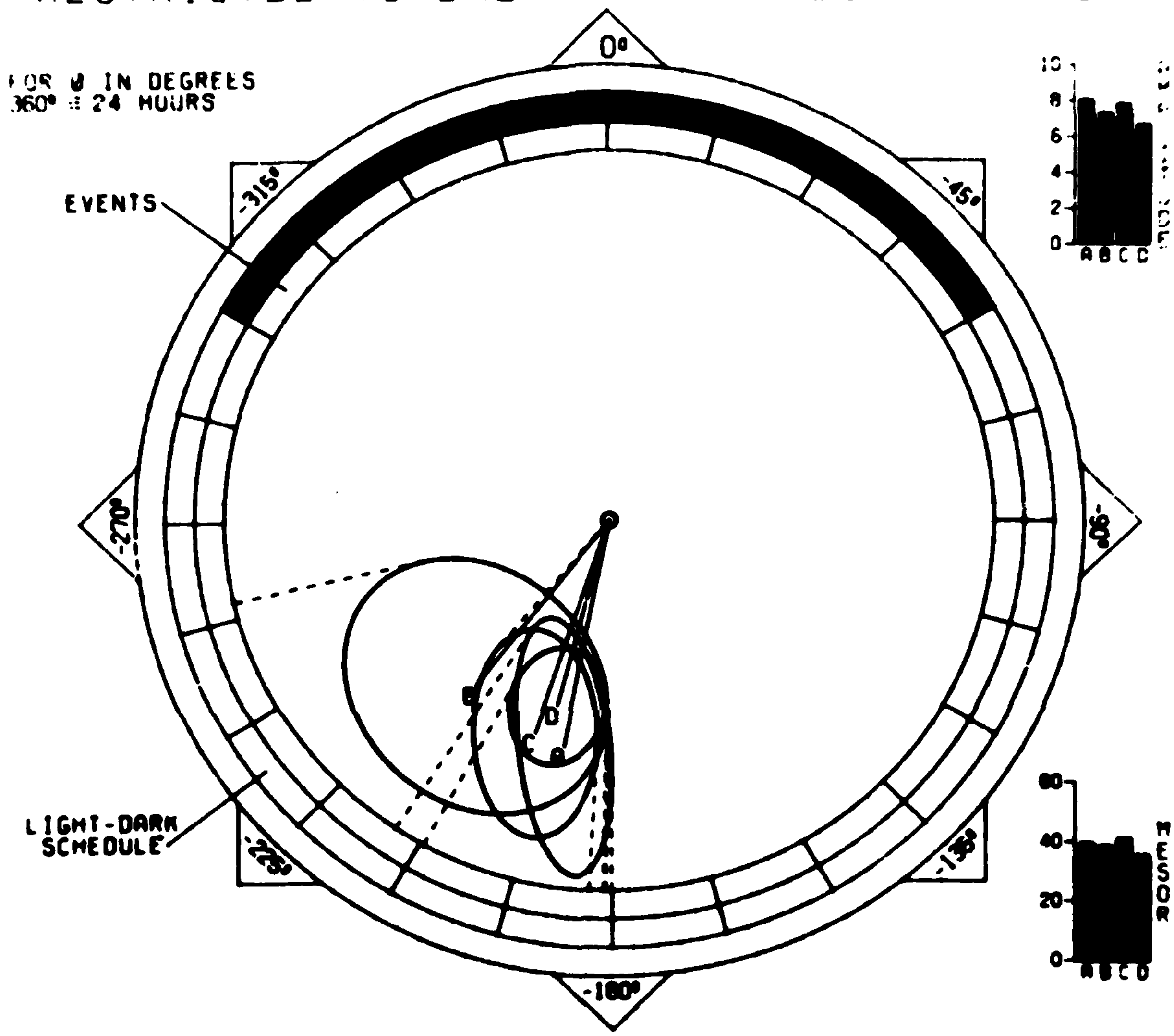
Performance: Adding Ratio

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M.	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	6	1.45	0.03	−162	−104	10	1.52	0.06	−229	−169	− 67	4	1.49	0.02	−174	−102
2	8	1.60	0.02	−153	−109	29*	1.64	0.08	−227	−179	−350	20*	1.65	0.04	−240	−189
4	57*	1.56	0.15	−249	−199	47*	1.59	0.14	−258	−204	− 10	33*	1.58	0.13	−242	−194
5	37*	1.51	0.08	−239	−190	71*	1.43	0.19	−211	−162	−348	53*	1.44	0.13	−223	−174
7	6	1.94	0.05	−245	−186	18	2.12	0.06	−161	−134	−335	7	2.14	0.04	−207	−159
51	43*	2.04	0.13	−268	−179	37*	2.08	0.14	−255	−182	−344	28*	2.06	0.10	−283	−198
53	39*	1.54	0.13	−248	−183	17	1.66	0.08	−266	−200	− 2	31*	1.63	0.11	−266	−198
54	17	1.94	0.07	−271	−192	13	2.09	0.04	−201	−133	−219	2	2.14	0.07	−359	−274
57	5	1.36	0.03	−170	− 96	32*	1.45	0.09	−325	−245	−350	6	1.31	0.04	−348	−255
58	21*	1.74	0.09	−258	−203	5	1.34	0.03	− 89	− 44	−189	13	1.32	0.06	−284	−215
59	17*	1.44	0.06	−250	−191	5	1.51	0.03	−244	−194	−290	3	1.60	0.02	−329	−264
61	12	1.29	0.05	−216	−156	22*	1.33	0.08	−223	−164	−311	5	1.28	0.03	−261	−213
62	12	1.20	0.06	−220	−162	8	1.31	0.06	− 58	−317	−315	5	1.25	0.05	− 65	− 2
64	10	1.36	0.07	−226	−184	16*	1.47	0.07	−238	−187	−352	8	1.56	0.05	−250	−195
66	1	1.60	0.01	−141	− 66	9	1.56	0.06	− 92	− 15	−153	3	1.55	0.03	−283	−222
68	17*	1.22	0.07	−226	−190	9*	1.24	0.03	−223	−190	−348	4	1.28	0.02	−229	−202
69	6	1.35	0.02	−303	−271	11*	1.57	0.03	−238	−206	−287	8	1.53	0.03	−306	−279
72	12	1.16	0.06	−306	−260	29*	1.29	0.08	−216	−180	−327	33*	1.36	0.09	−275	−213
70						27*	2.05	0.09	−175	−139	− 5	9	1.94	0.08	−159	−134
	Ad Libitum					Ad Libitum						Ad Libitum				
3	18*	1.52	0.06	−214	−173	24*	1.48	0.07	−209	−160		13	1.63	0.04	−166	−120
6	55*	1.51	0.18	−230	−181	24*	1.64	0.08	−224	−178		46*	1.71	0.14	−242	−186
56	44*	1.38	0.13	−261	−190	49*	1.41	0.09	−296	−231		55*	1.41	0.10	−252	−189
63	14	1.44	0.08	−242	−172	8	1.49	0.04	−288	−219		15*	1.52	0.06	−265	−183
70	9	1.72	0.03	−122	− 89	6	1.91	0.03	−168	−139		40*	1.96	0.11	−206	−172
73						11	1.34	0.04	−227	−155		35*	1.43	0.06	−251	−189

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (reffered to acrophase of same subject on dinner)
*P $\leq$ 0.05

FIGURE 23

CIRCADIAN RHYTHM IN LEFT GRIP OF SUBJS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	40	8.1 (3.8 12.5)	-191 (-180 -214)
B BRKFST ONLY	<0.001		19	39	7.3 (3.3 11.4)	-218 (-181 -258)
C DINNER ONLY	<0.001		19	41	7.9 (4.4 11.4)	-199 (-183 -[illegible])
D CONTROLS	<0.001		17	36	6.7 (4.6 8.8)	-195 (-181 -209)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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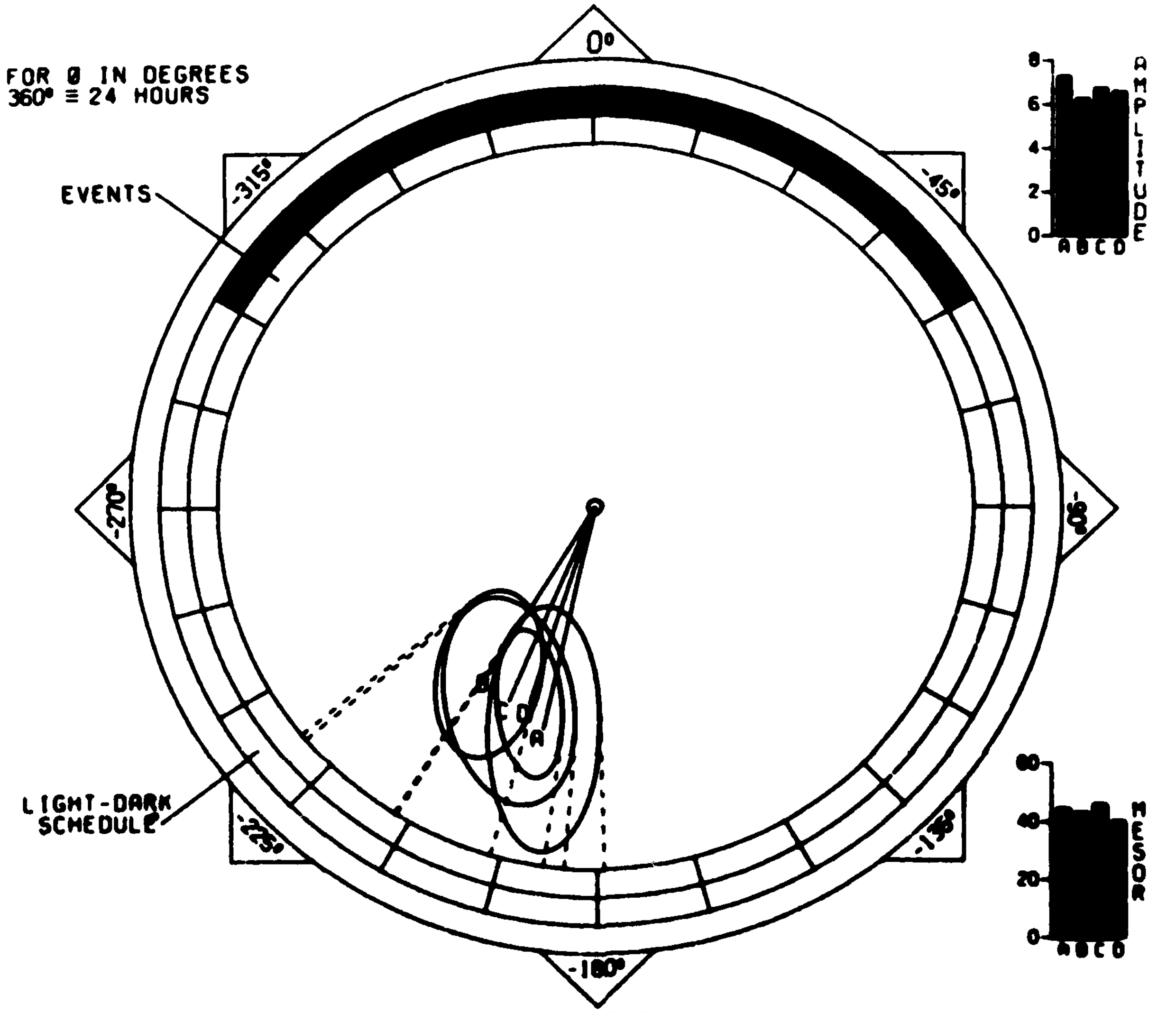
FIGURE 24

CIRCADIAN RHYTHM IN RT GRIP OF SUBJECTS RESTRICTED TO BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB	<0.001		18	45	7.3 (3.5 11.2)	−193 (−179 −213)
B BRKFST ONLY	<0.001		19	43	6.3 (3.7 8.9)	−212 (−196 −231)
C DINNER ONLY	<0.001		19	46	6.8 (3.9 9.9)	−203 (−185 −230)
D CONTROLS	<0.001		17	41	6.6 (4.4 8.9)	−198 (−188 −212)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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Table 36

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

Performance: Left Grip Strength

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	27*	97.96	4.34	−292	−234	36*	98.41	4.94	−307	−247	− 55	26*	99.37	4.08	−264	−192
2	10	44.99	1.39	−225	−181	38*	46.25	2.36	−233	−185	−329	13	47.35	1.08	−267	−216
4	48*	110.60	12.97	−247	−197	43*	116.54	15.03	−254	−200	−343	27*	116.15	10.69	−265	−217
5	19*	98.90	9.68	−235	−186	48*	96.20	6.65	−239	−190	−347	68*	97.89	8.70	−242	−193
7	3	106.42	2.31	−269	−210	7	106.87	3.82	−230	−203	− 15	18	101.03	14.40	−284	−201
51	64*	95.10	13.70	−284	−195	24*	84.70	5.60	−274	−199	−348	53*	136.60	14.40	−284	−201
53	26*	13.65	0.71	−276	−211	33*	14.51	1.01	−267	−201	−338	36*	13.92	0.66	−291	−223
54	2	14.06	0.20	−295	−216	2	14.07	0.26	− 76	− 8	−196	28*	14.21	0.80	−257	−172
57	29*	9.59	1.44	−254	−180	24*	9.46	0.57	−283	−203	− 15	14	10.37	0.68	−281	−188
58	6	7.88	0.37	−239	−184	20*	7.65	1.47	−248	−203	−321	37*	8.16	1.12	−311	−242
59	16	8.11	0.63	−276	−217	5	7.64	0.39	−242	−192	−309	32*	6.68	0.66	−308	−243
31	29*	42.27	5.34	−239	−179	37*	39.28	9.84	−261	−202	− 12	20*	42.39	4.19	−238	−190
62	2	17.55	0.22	−261	−203	3	18.67	0.54	−279	−108	− 59	6	17.66	0.33	−112	− 49
64	33*	15.77	0.53	−261	−219	12	17.18	0.50	−241	−190	−342	30*	17.53	0.57	−263	−208
66	24*	12.00	0.57	−269	−194	23*	13.21	0.45	−306	−229	−341	13	12.80	0.28	−309	−248
68	56*	9.60	2.71	−215	−179	42*	10.07	1.52	−241	−208	− 31	44*	10.43	1.98	−204	−177
69	30*	5.44	0.73	−211	−179	4	7.16	2.30	−319	−287	−105	36*	6.12	0.88	−209	−182
72	19*	5.73	0.59	−211	−165	30*	6.70	0.56	−271	−235	− 40	29*	6.22	0.51	−257	−195
70						42*	22.49	1.21	−270	−234	− 43	18*	20.87	4.48	−216	−191
	Ad Libitum					Ad Libitum						Ad Libitum				
3	16*	56.94	4.68	−223	−182	24*	59.53	4.74	−232	−183		21*	58.95	4.40	−214	−168
6	56*	95.13	12.40	−233	−184	34*	94.17	9.69	−225	−179		37*	96.95	7.31	−242	−186
56	55*	7.70	0.54	−271	−200	61*	7.74	0.44	−283	−218		81*	7.72	0.42	−273	−210
63	35*	17.35	1.21	−277	−207	5	17.72	0.50	−288	−219		29*	17.25	1.10	−279	−197
70	40*	16.64	1.64	−254	−221	58*	17.61	1.67	−246	−217		42*	18.12	1.61	−245	−211
73						5	10.43	0.36	−214	−142		<1	10.82	0.08	−179	−117

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P < 0.05

Table 37

IMPUTATIONS BY LEAST SQUARES FIT OF 24–h COSINE FUNCTION TO DATA ON 3 FEEDING REGIMENS (LAST WEEK OF EACH STAGE)

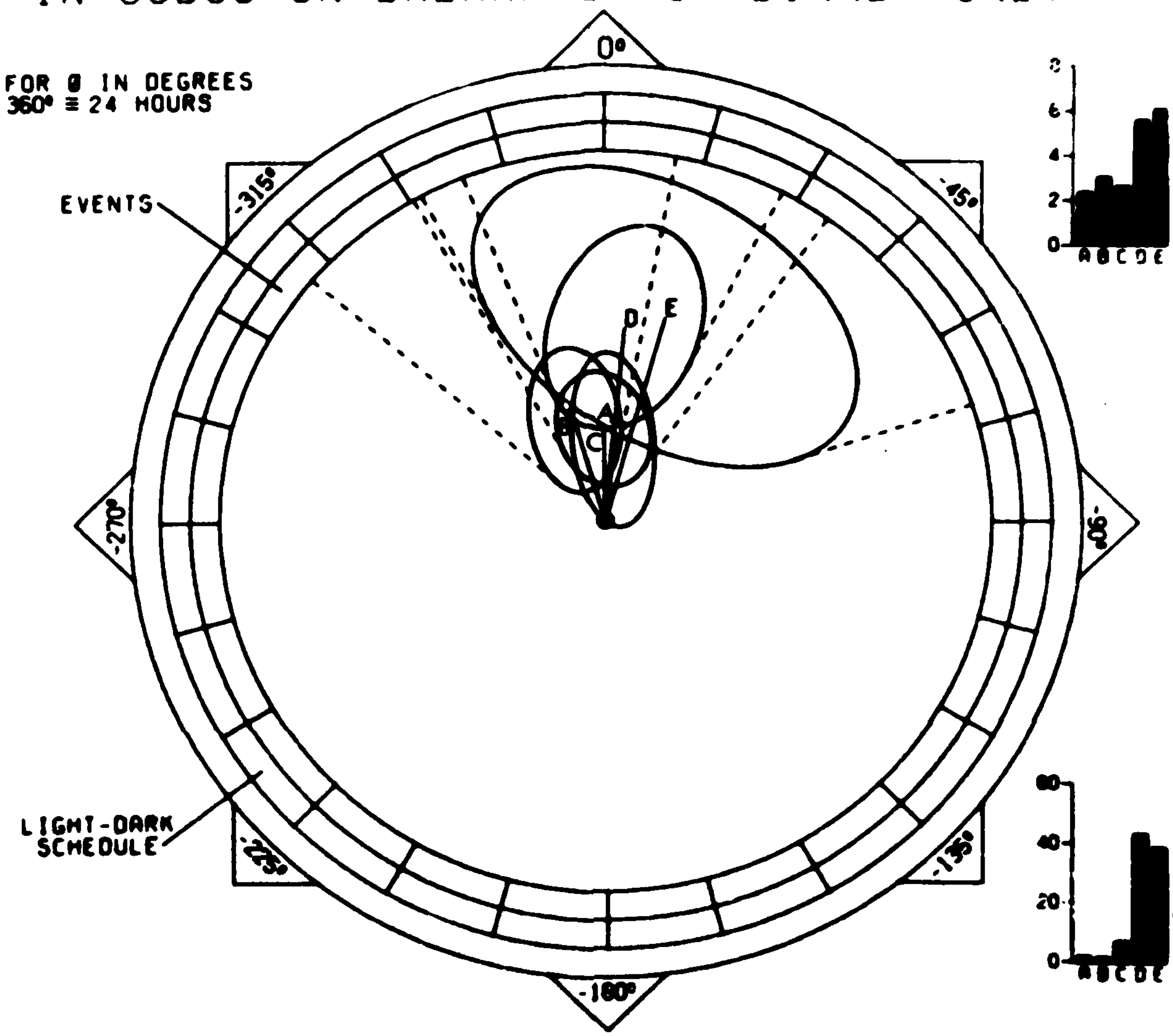
Performance: Right Grip Strength

	Ad Libitum					Breakfast						Dinner				
Subj.	PR	M	A	ϕ	φ	PR	M	A	ϕ	φ	Φ	PR	M	A	ϕ	φ
1	28*	121.85	6.87	−272	−214	42*	125.75	6.33	−308	−248	− 33	27*	124.02	5.31	−287	−215
2	14*	48.93	1.85	−225	−181	47*	50.74	2.52	−234	−186	−272	16*	50.47	1.12	−325	−274
4	50*	120.47	13.40	−248	−198	42*	113.43	13.66	−266	−212	− 6	25*	120.23	11.12	−254	-206
5	24*	115.69	15.41	−250	−201	48*	115.72	6.25	−244	−195	− 4	75*	117.97	9.20	−240	−191
7	5	108.14	2.24	−281	−222	16	112.74	6.56	−270	−243	−355	6	114.36	2.94	−296	−248
51	63*	97.10	9.60	−287	−198	17*	83.40	4.30	−292	−219	− 24	61*	138.60	12.70	−280	−195
53	39*	16.00	0.71	−277	−212	16	16.43	0.83	−248	−182	−331	49*	16.41	0.76	−279	−211
54	20	14.22	0.72	−239	−160	16	15.18	0.52	−329	−261	− 73	18	15.42	0.57	−273	−188
57	33*	11.96	1.52	−290	−216	20*	11.62	0.61	−266	−186	−352	25*	12.48	0.94	−286	−193
58	7	8.55	0.49	−254	−199	24*	8.34	1.08	−273	−228	−348	38*	8.28	1.24	−312	−243
59	13	7.41	0.49	−294	−235	22*	6.42	0.52	−220	−170	−279	14	5.57	0.37	−316	−251
61	18*	60.02	5.43	−241	−181	33*	61.84	7.91	−262	−203	−360	19*	56.44	6.81	−245	−203
62	2	17.50	0.16	−100	− 42	14	18.47	0.69	−321	−220	− 63	12	17.97	0.41	−220	−157
64	29*	17.39	0.43	−249	−207	18*	18.48	0.38	−297	−246	− 23	21*	18.61	0.38	−278	−223
66	14*	12.54	0.33	−280	−205	29*	14.42	0.48	−308	−231	− 8	15*	13.70	0.41	−284	−223
68	51*	10.44	2.72	−217	−181	49*	10.66	1.88	−226	−193	− 21	56*	11.12	2.36	−199	−172
69	25*	6.51	0.70	−201	−169	25*	7.48	0.55	−279	−247	− 62	47*	7.49	1.15	−212	−185
72	14*	7.93	0.70	−209	−163	42*	8.34	0.62	−250	−214	−10	27*	8.66	0.48	−266	−204
70						18*	23.76	0.61	−265	−229	− 22	18*	22.49	1.78	−232	−207
	Ad Libitum					Ad Libitum						Ad Libitum				
3	32*	65.75	7.42	−234	−193	25*	67.21	5.44	−248	−199		24*	67.78	5.25	−219	−173
6	61*	108.67	15.73	−234	−185	39*	110.55	11.10	−233	−187		42*	111.95	10.40	−239	−183
56	46*	7.43	0.44	−271	−200	62*	7.47	0.44	−289	−224		77*	7.48	0.46	−274	−211
63	24*	17.32	1.11	−291	−221	13	17.90	0.66	−278	−209		21*	16.76	1.37	−276	−194
70	32*	19.33	0.76	−262	−229	48*	19.63	1.15	−251	−222		20*	19.04	0.91	−247	−213
73	–	––	––	––	––	1	12.53	0.10	−173	−101		15	12.06	0.64	−258	−196

PR = percent rhythm; M = mesor (rhythm determined average); A = Amplitude; ϕ = computative acrophase
φ = acrophase referred to middle of habitual dark span in bedroom
Φ = internal acrophase (referred to acrophase of same subject on dinner)
*P < 0.05

FIGURE 25

CIRCADIAN PHASE RELATIONS AMONG RHYTHMS IN SUBJS ON BREAKFAST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)			ACROPHASE (Ø) (95% CL)		
A TAPPING	0.051		18	1.91	2.36	(	)	-5	(	)
B ADDING	0.004		18	1.60	3.06	0.97	5.2	-344	-311	-11
C FNGR CNTING	0.002		18	7.0	2.66	1.02	4.3	-359	-331	-35
D RT GRIP	<0.001		19	43	5.6	2.65	8.6	-5	-339	-27
E LEFT GRIP	0.001		19	39	6.1	2.42	10.3	-16	-332	-71

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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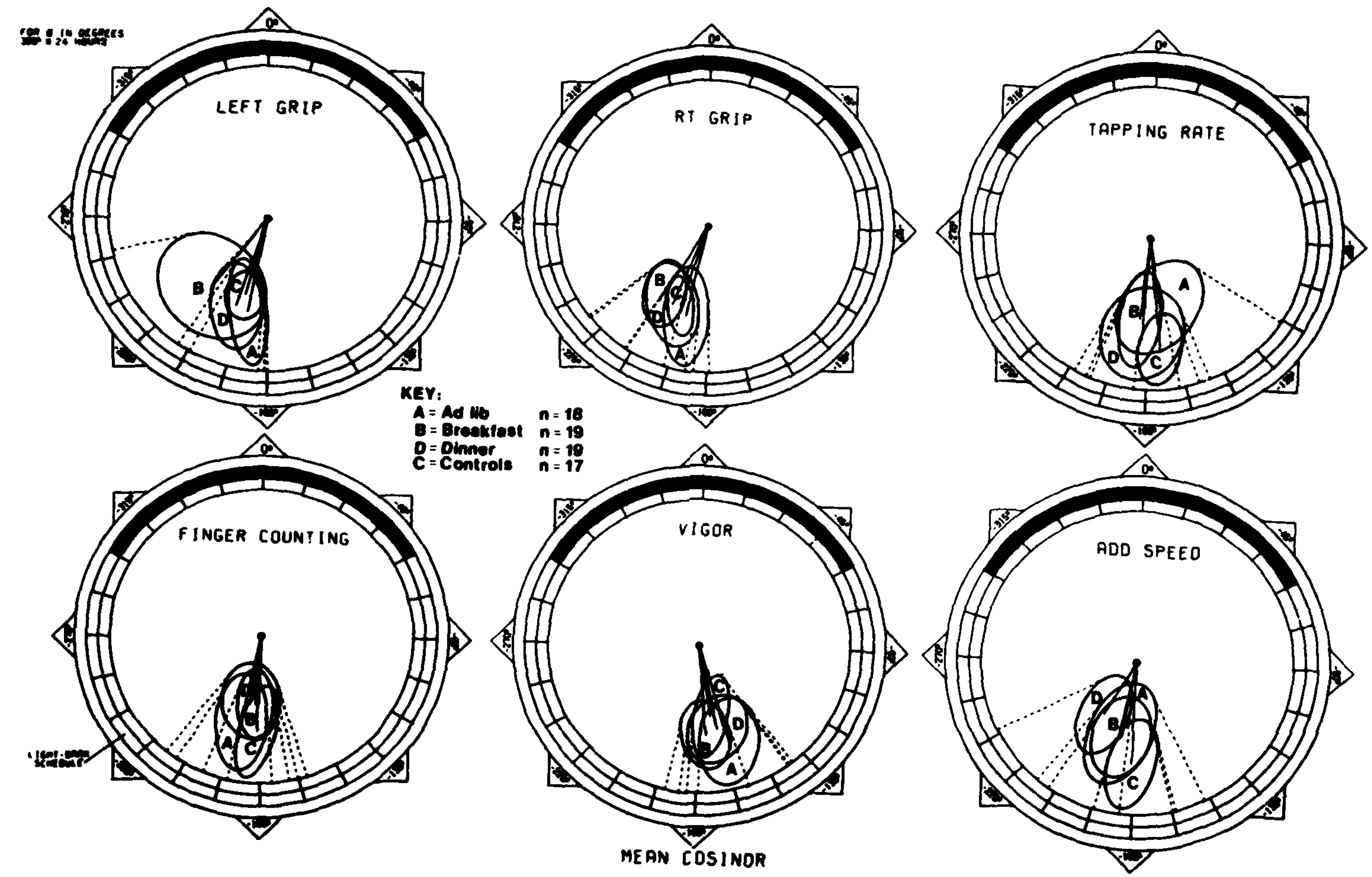
FIGURE 26

CIRCADIAN RHYTHMIC PERFORMANCE ON DIFFERENT MEAL-SCHEDULES



self-administered several times a day for twelve weeks. Although subjects were thoroughly instructed on how to carry out each task, there is always the built-in potential for subject-to-subject variability in such a situation. For instance, individuals may differ in terms of task strategy, maximum permissible errors (i. e., accuracy criteria), response topography, and intertrial variability for a given task. These factors, plus others, can serve to make a self-administered task less demanding and less accurate than a similar experimenter-administered task. Thus, there is a need to re-examine the question of mealtiming and performance rhythms by using more objective, difficult tasks to include some which tap other types of behavioral functioning such as attentiveness and reaction speed.

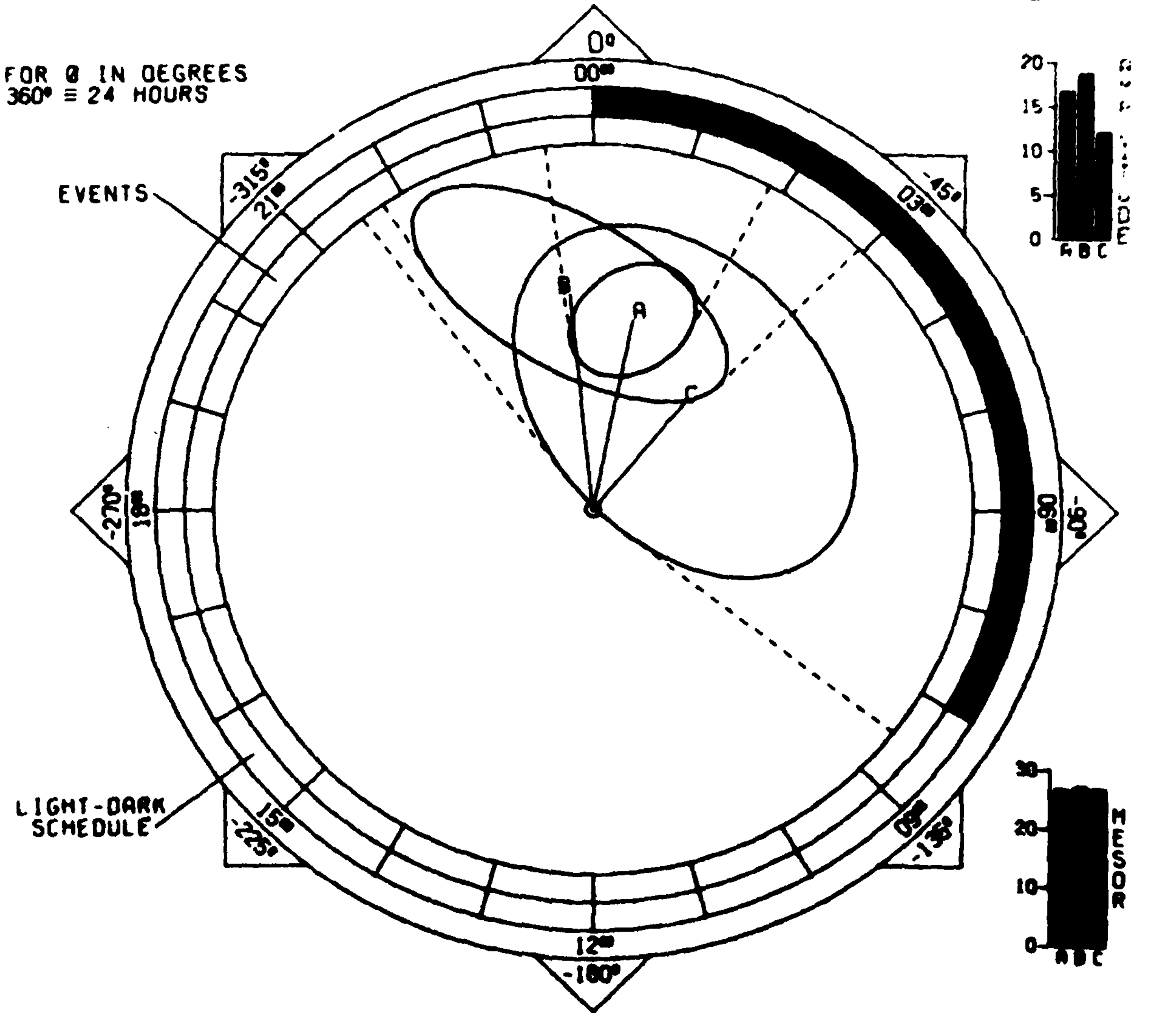
Blood constituents. Shifts in the timing of a single daily meal produced dramatic, but differential, shifts in the circadian timing of the measured constituents of the subjects' blood. The mean cosinor results for six of these constituents are shown in Figures 27 to 32 and are summarized in Figure 33. The results for chloride and blood urea nitrogen (BUN) are shown in Figures 34 to 36. In these polar plots the data from the control subjects and from the experimental subjects during Stage IV have been combined (N=34) into a single **ad libitum** cosinor. Also, the acrophases are plotted relative to the time of sleep onset (rather than midsleep).

Note first the similar shifts in the timing of the circadian rhythms for the number of lymphocytes and white blood cells. The change in the acrophase of serum iron from about typical lunchtime to a time corresponding to the single daily meal is not surprising. Similarly, one might expect shifts in the timing of BUN and chloride but not necessarily to different extents. Even more important is the effect of mealtime restriction on the circadian timing of the three hormones which are intimately related to carbohydrate metabolism: cortisol, plasma growth hormone (STH), and insulin. The insulin acrophase is shifted toward the mealtime from the **ad libitum** condition under both the Dinner-only and Breakfast-only conditions; however, the extent of shift is greater for Breakfast-only. The presence of an acrophase shift for the other two hormones depends on the time of the single daily meal. For cortisol the shift occurs on Dinner-only, while for STH the shift occurs on Breakfast-only.

Thus it appears that these three circadian hormonal rhythms adjust differently to imposed changes in mealtiming. This phenomenon is more readily apparent in Figures 37 and 38. The top half of Figure 37 depicts the acrophase and 95% confidence arc for each hormonal rhythm as a function of Breakfast-only or Dinner-only. The bottom half does the same for insulin and glucagon based on the findings of a study similar to this one which provided subjects a fixed 2000-calorie meal for one week as Breakfast-only and one week for Dinner-only (unpublished data from Halberg). In terms of the generality of our findings, it is important to observe that the insulin rhythm was shifted similarly in both studies. Figure 38 indicates the different extents of shifting as a result of changing mealtime from Breakfast-only to Dinner-only in both studies.

FIGURE 27

EFFECT OF MEAL-TIMING ON LYMPH (X 10^2)
IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB • REG	<0.001		34	26.8	16.7 (11.7 21.9)	-11 (-353 -27)
B BRKFST ONLY	<0.001		9	27.1	18.7 (10.1 30.3)	-354 (-326 -44)
C DINNER ONLY	0.047		8	26.8	12.1 (0.22 24.8)	-39 (-323 -127)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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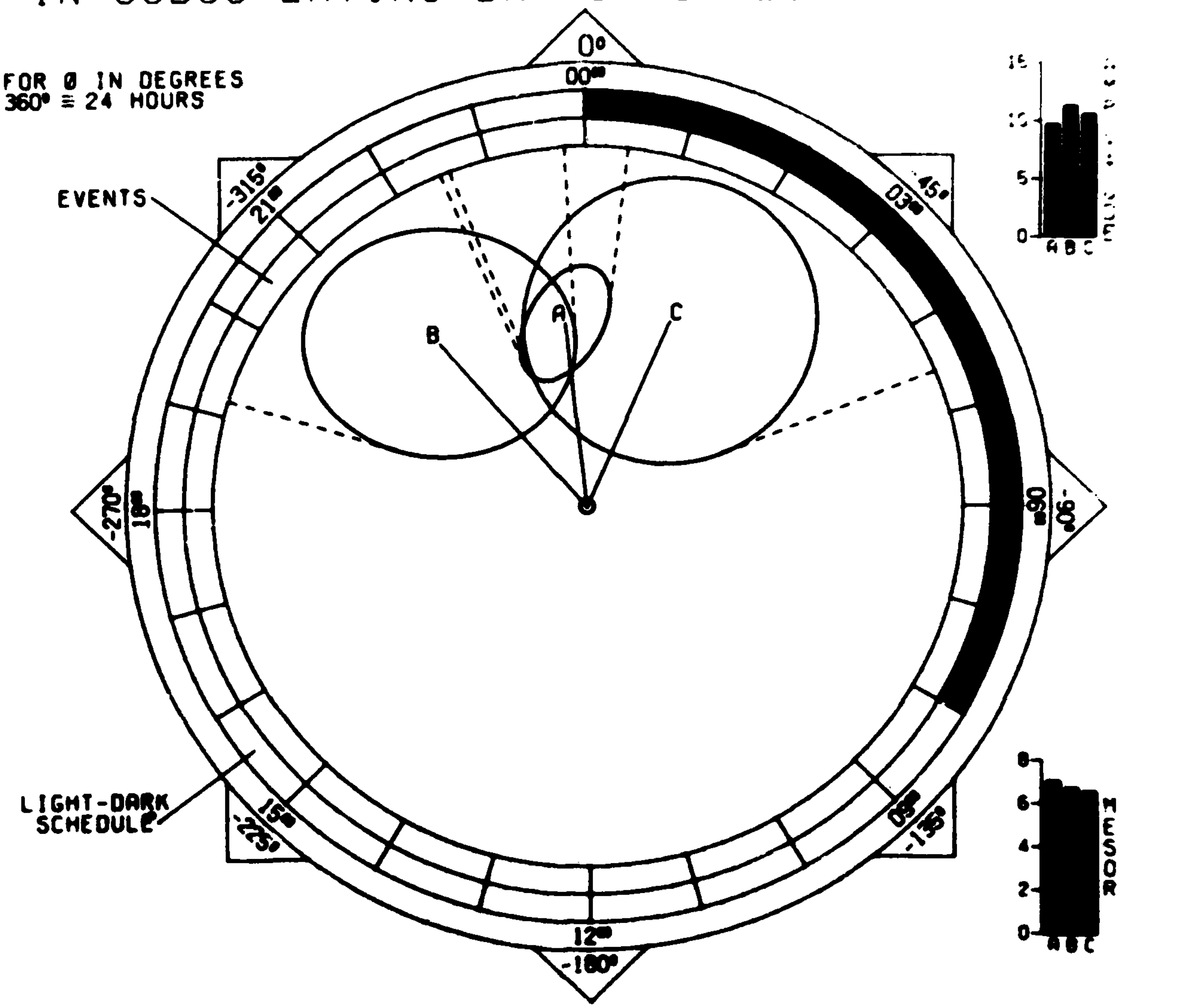
FIGURE 28

EFFECT OF MEAL-TIMING ON WBC (X 10^3)
IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB • REG	<0.001		34	7.1	9.7 (6.8 12.6)	-354 (-337 -7)
B BRKFST ONLY	0.003		9	6.7	11.3 (4.9 17.8)	-320 (-287 -357)
C DINNER ONLY	0.012		8	6.6	10.6 (3.06 18.1)	-24 (-339 -68)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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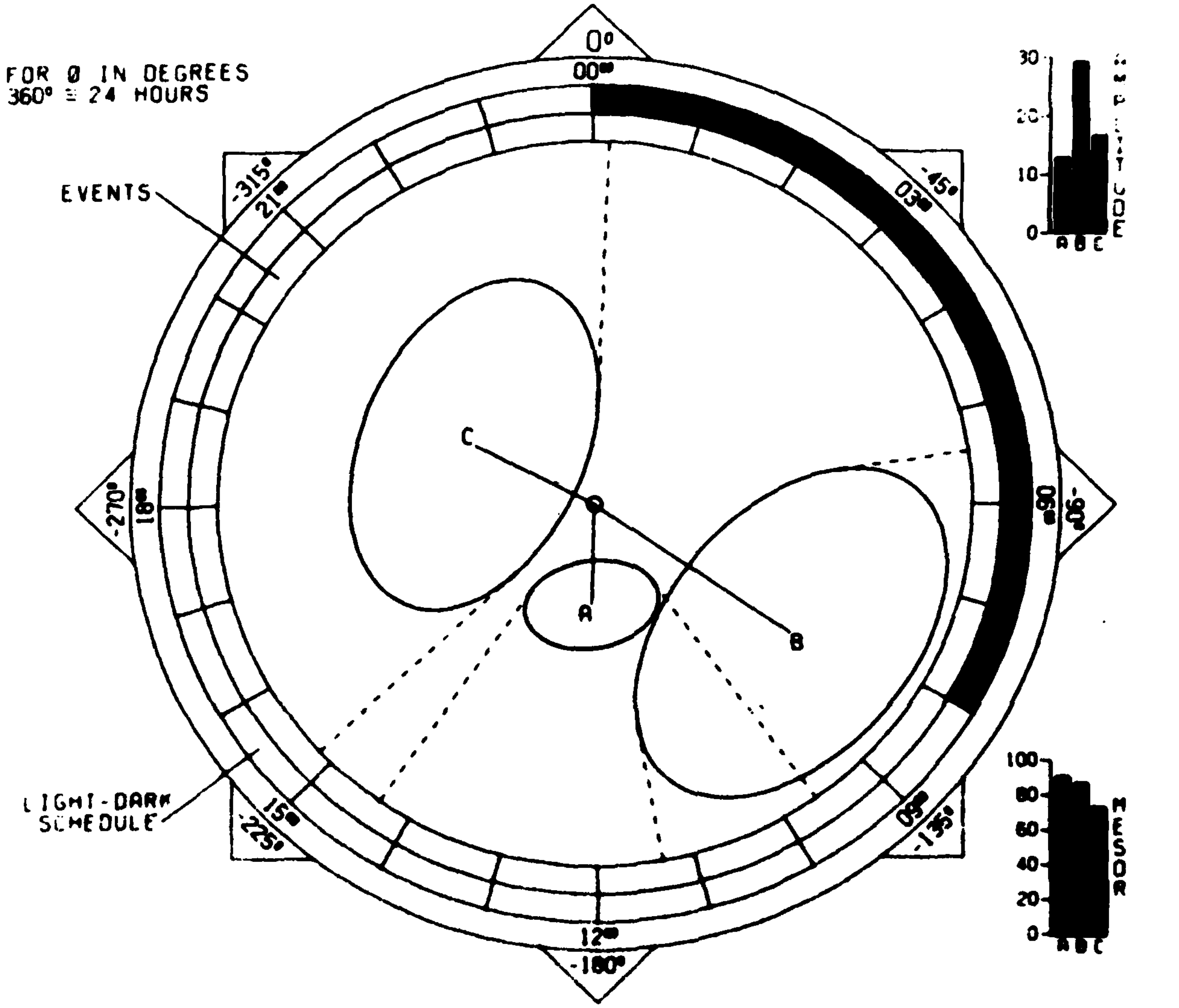
FIGURE 29

EFFECT OF MEAL-TIMING ON IRON
IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB • REG	<0.001		34	91	12.9 (7.2 18.8)	-182 (-144 -215)
B BRKFST ONLY	0.003		8	87	29.4 (14.0 45)	-124 (-81 -170)
C DINNER ONLY	0.024		8	73	16.7 (2.77 31.6)	-297 (-227 -3)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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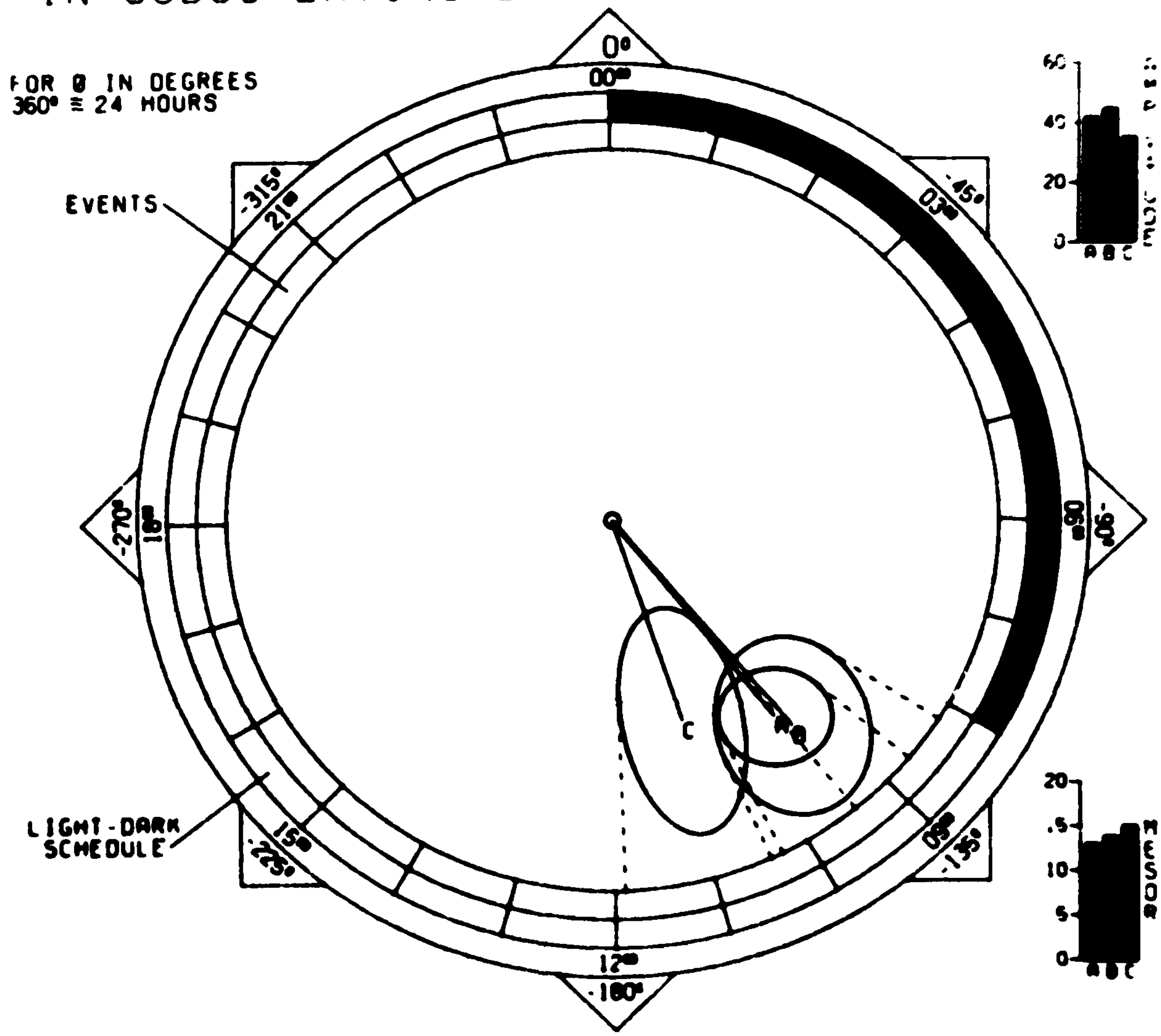
FIGURE 30

EFFECT OF MEAL-TIMING ON CORTISOL IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

AMPLITUDES ARE AS PERCENT OF MESOR

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB REG	<0.001		34	13.1	42 (33 51)	-142 (-130 -154)
B BRKFST ONLY	<0.001		9	13.9	45 (30.1 60)	-140 (-122 -156)
C DINNER ONLY	0.002		9	15.1	35 (16.2 54)	-162 (-141 -178)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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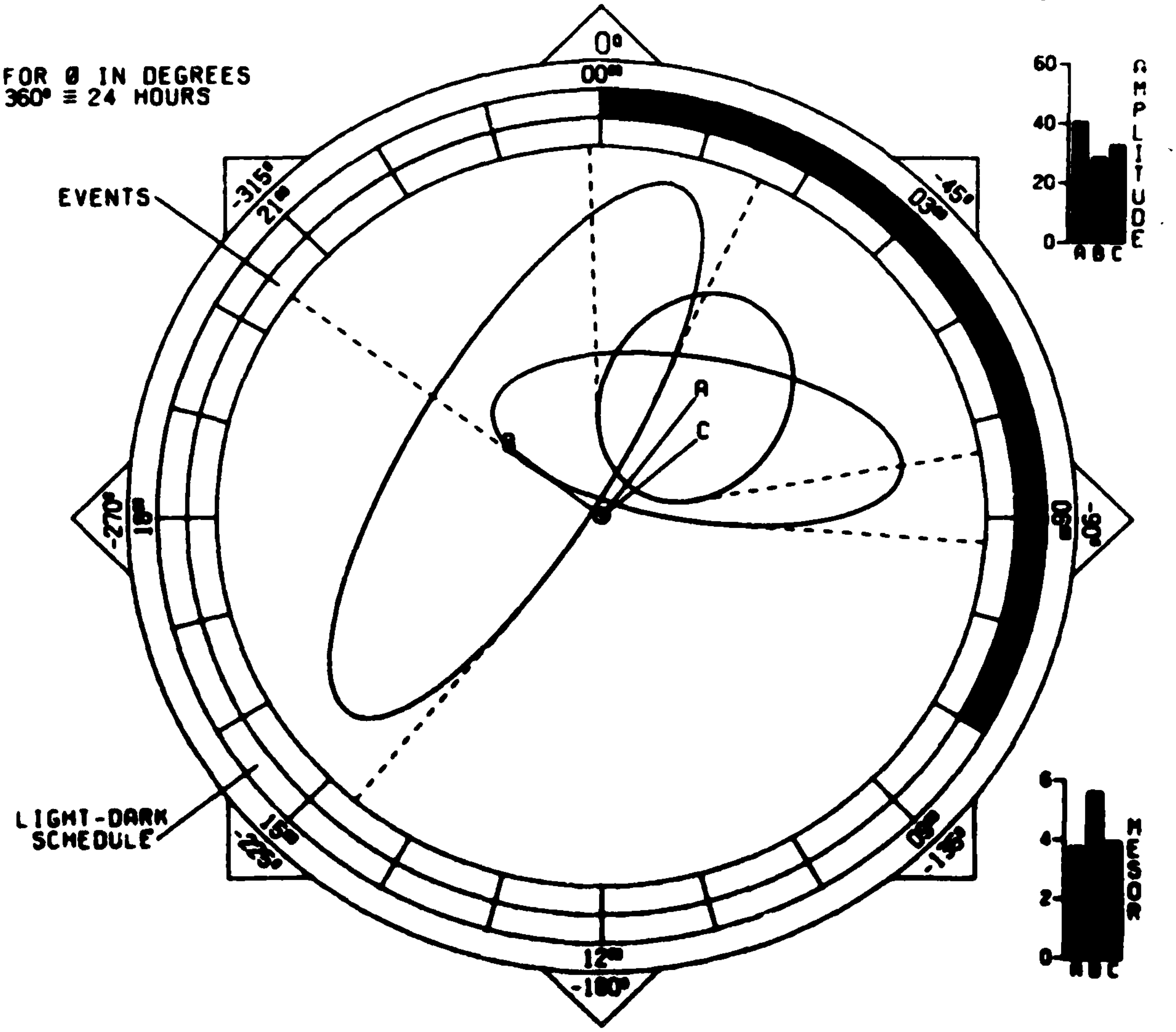
FIGURE 31

EFFECT OF MEAL-TIMING ON STH
IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB • REG	0.005		34	3.7	40 (11.1 70)	-37 (-358 -80)
B BRKFST ONLY	0.035		8	5.6	28.4 (2.41 96)	-309 (-220 -24)
C DINNER ONLY	0.026		8	3.9	33 (4.3 79)	-50 (-307 -94)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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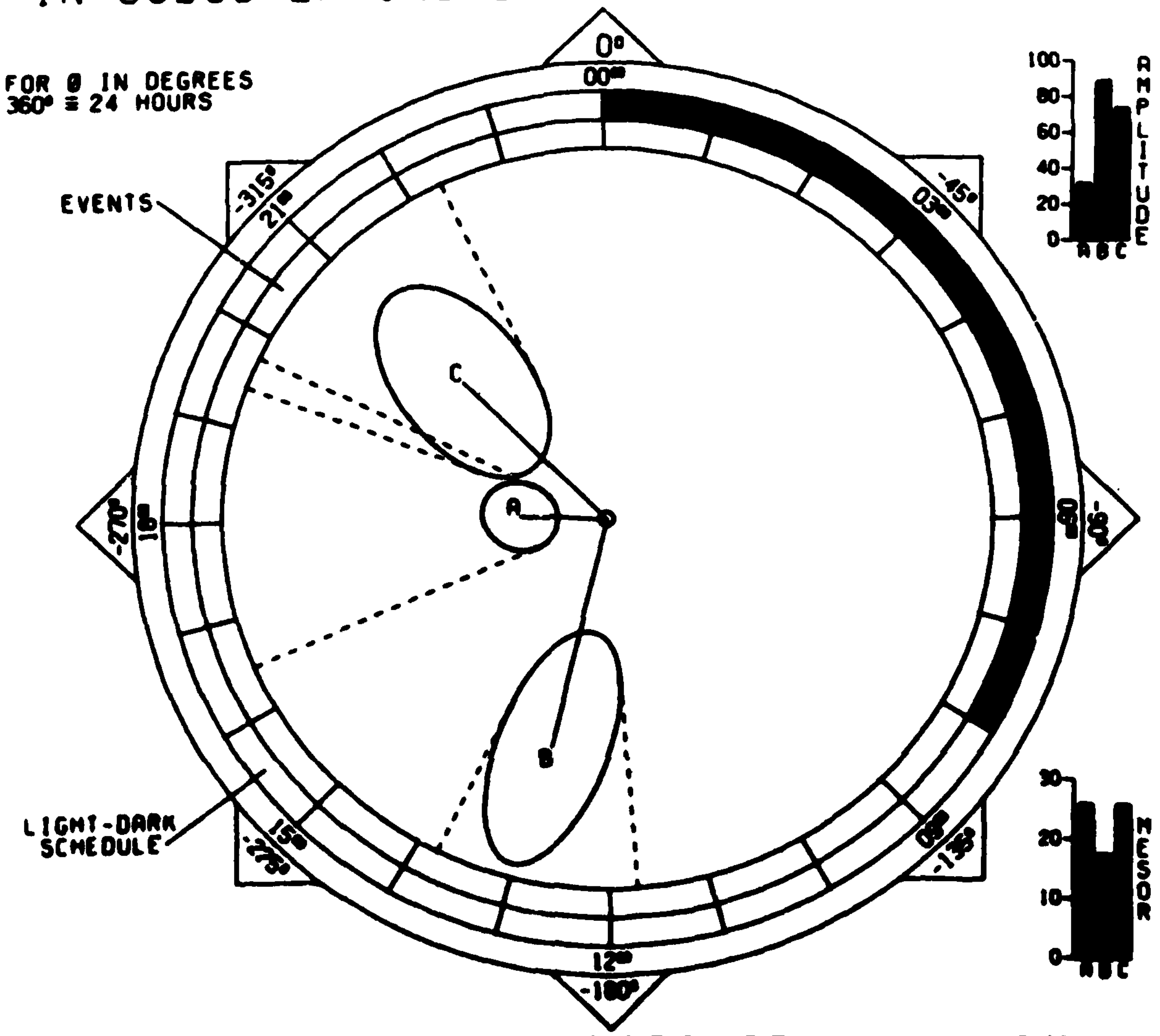
FIGURE 32

EFFECT OF MEAL-TIMING ON INSULIN IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB • REG	<0.001		34	25.9	31.5 (17.7 45)	-273 (-247 -296)
B BRKFST ONLY	0.002		9	17.5	89 (43 135)	-193 (-176 -207)
C DINNER ONLY	0.003		9	25.7	74 (32 115)	-315 (-291 -335)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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FIGURE 33

MEAL-SCHEDULING MODIFIES INTERNAL CIRCADIAN TIMING IN HUMAN BLOOD

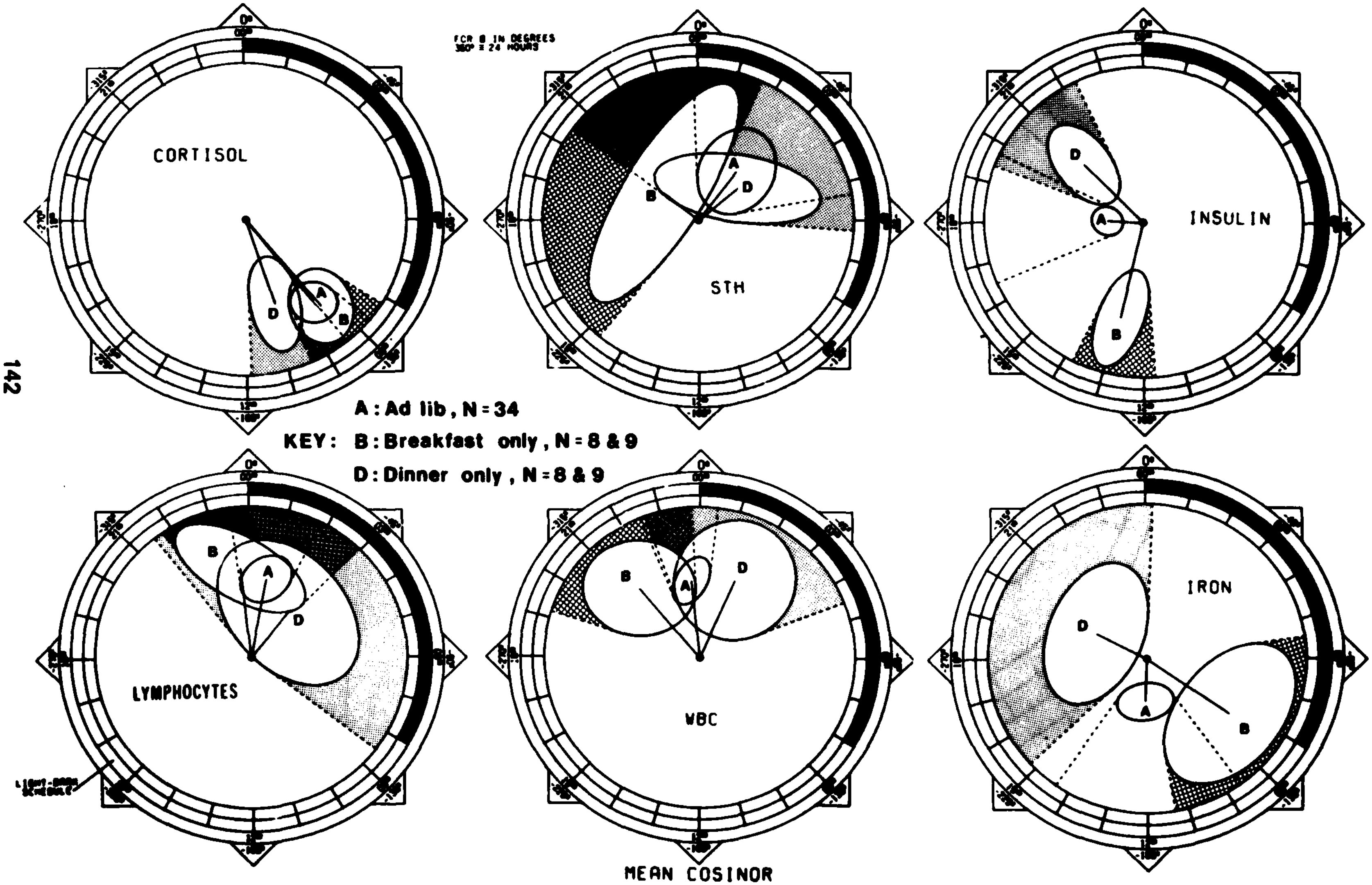
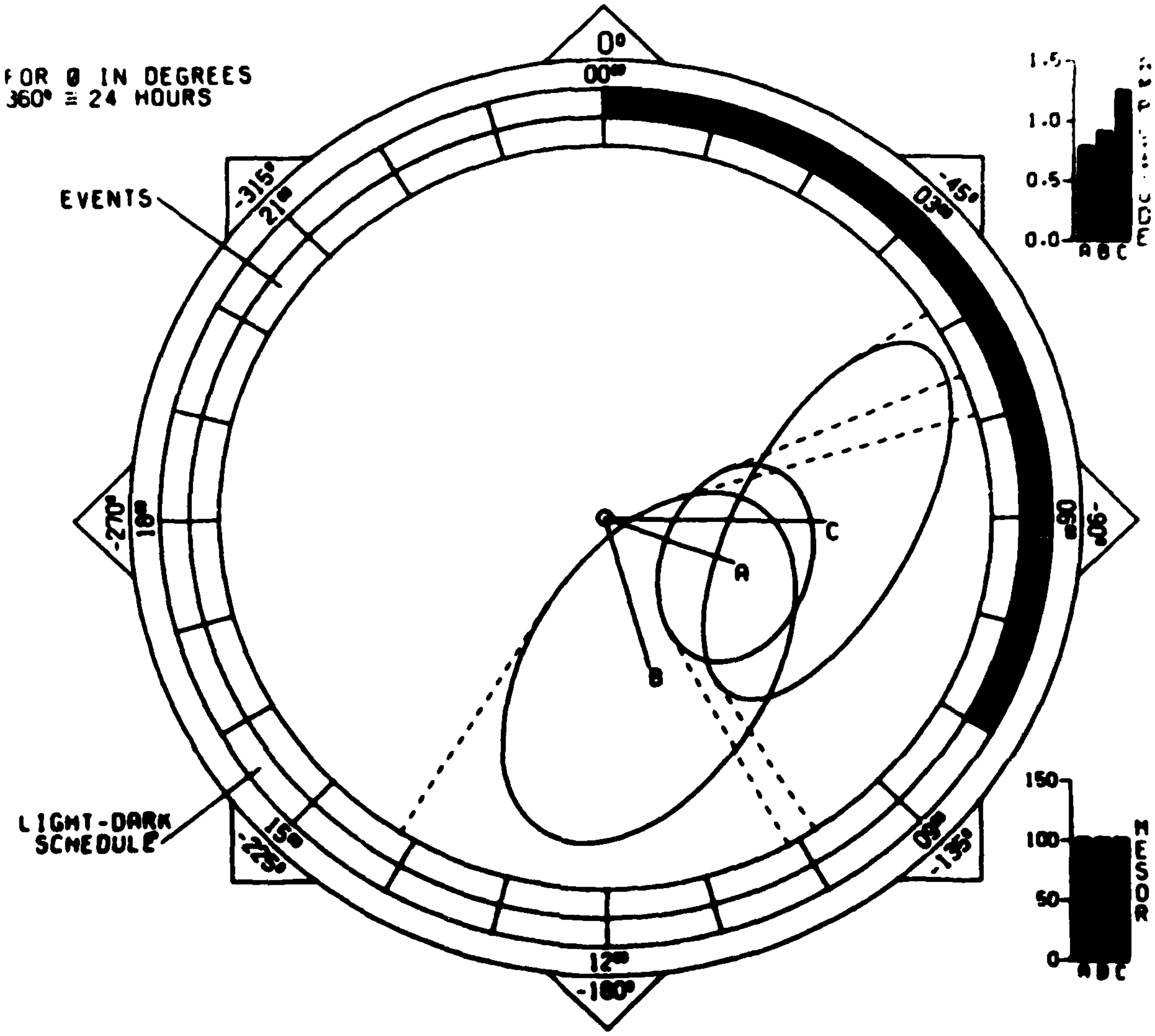


FIGURE 34

EFFECT OF MEAL-TIMING ON BLOOD CL IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB + REG	<0.001		30	102	0.79 (0.37 1.21)	-110 (-67 -152)
B BRKFST ONLY	0.030		9	102	0.92 (0.10 1.93)	-164 (-74 -212)
C DINNER ONLY	<0.001		9	103	1.26 (0.67 2.12)	-91 (-56 -147)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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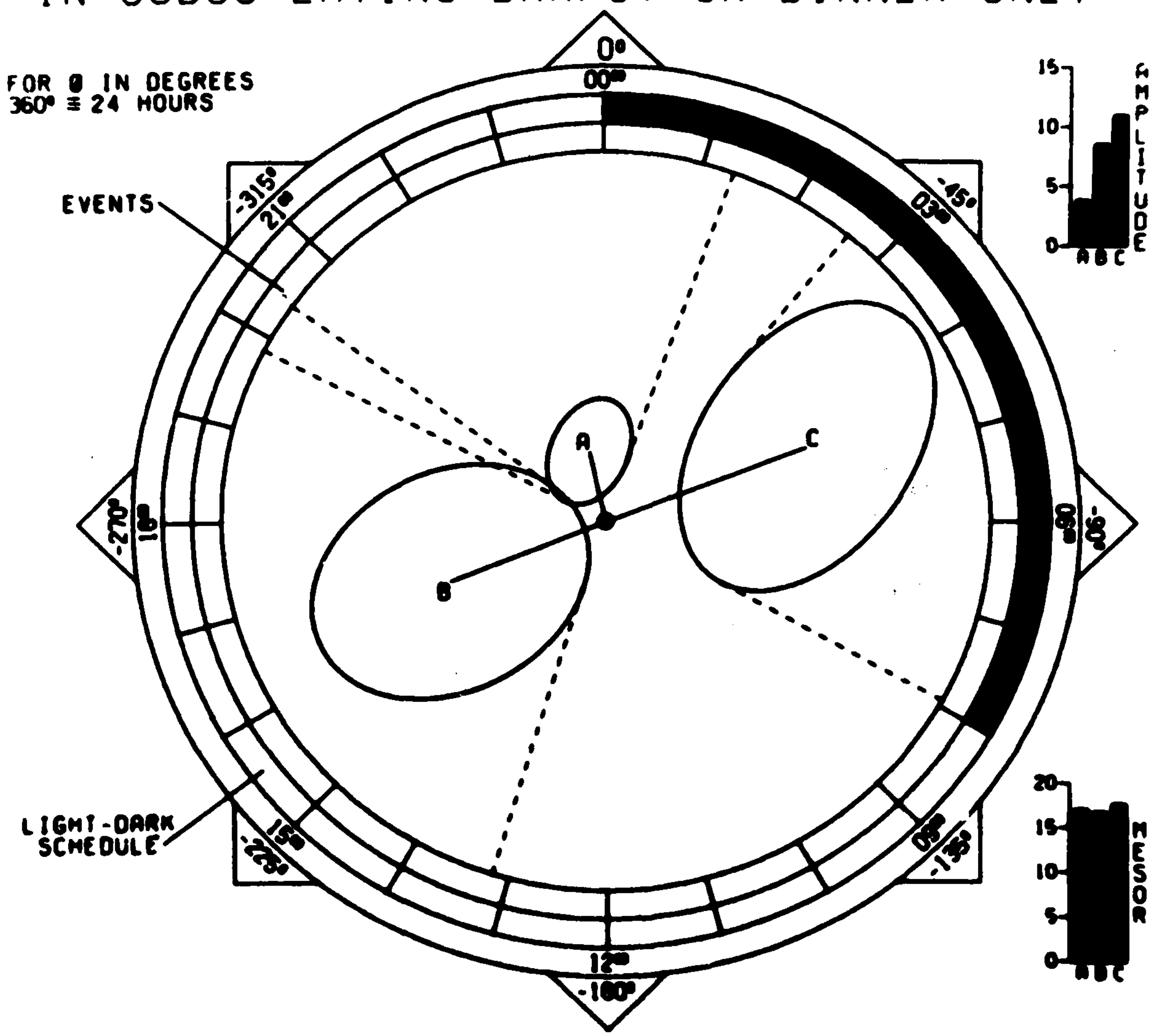
MINNEAPOLIS MINNESOTA 55455 USA PHONE (617) 373-2920

FIGURE 35

EFFECT OF MEAL-TIMING ON BUN IN SUBJS EATING BRKFST OR DINNER ONLY



MEAN COSINOR

(AMPLITUDES ARE AS PERCENT OF MESOR)

KEY TO ELLIPSES	P	NO OBS.	NO. SER.	MESOR	AMPLITUDE (95% CL)	ACROPHASE (Ø) (95% CL)
A AD LIB REG	0.002		34	17.1	3.8 (1.26 6.6)	-348 (-298 -20)
B BRKFST ONLY	0.028		9	16.8	8.5 (1.11 16.0)	-248 (-197 -306)
C DINNER ONLY	0.006		9	17.8	11.0 (3.8 18.9)	-69 (-39 -119)

P = PROBABILITY OF HYPOTHESIS AMPLITUDE = 0 NO. OBS. = NUMBER OF OBSERVATIONS
NO. SER. = NUMBER OF SERIES USED BY THE MEAN COSINOR TECHNIQUE TO FIND ELLIPSE
95% CL = CONSERVATIVE 95% CONFIDENCE LIMITS DERIVED FROM COSINOR ELLIPSE

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FIGURE 36

MEAL-SCHEDULING MODIFIES INTERNAL CIRCADIAN TIMING IN HUMAN BLOOD

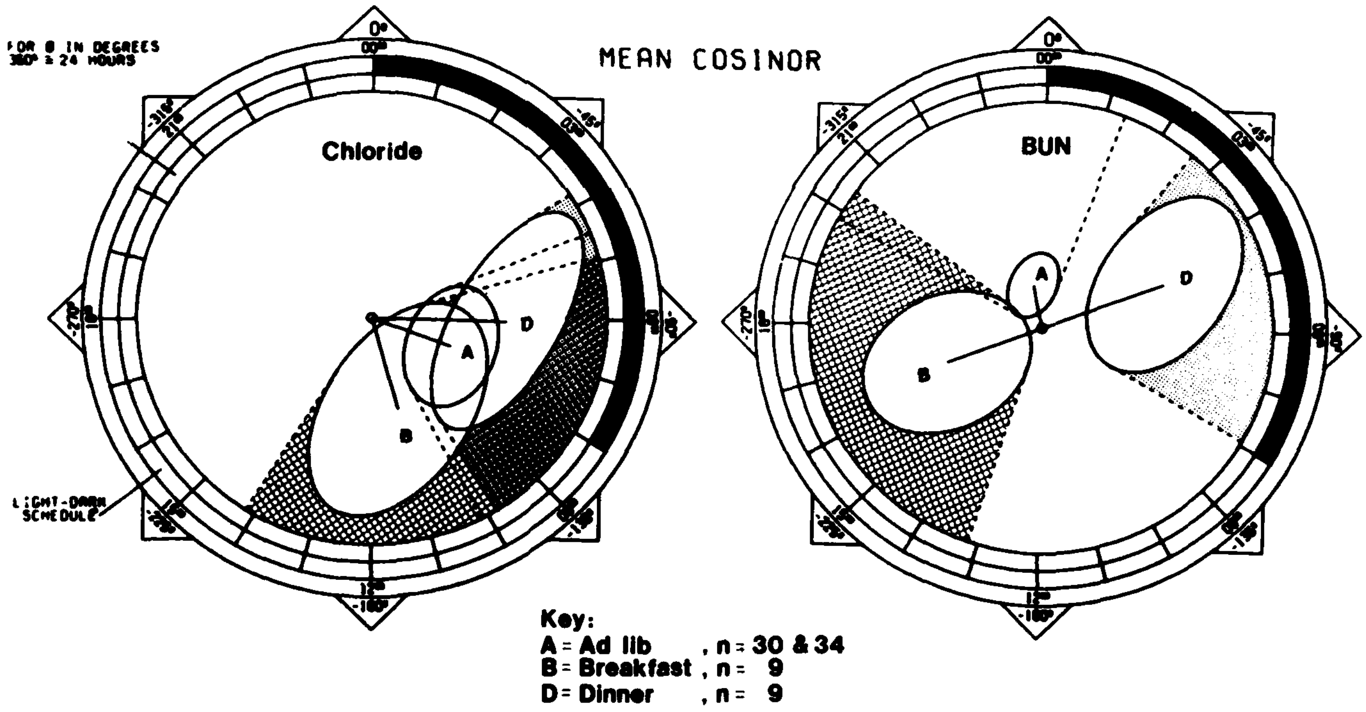


FIGURE 37

Circadian Acrophase Differences of Hormonal Variables Related to Carbohydrate Metabolism --As a Function of Timing a Single Daily Meal

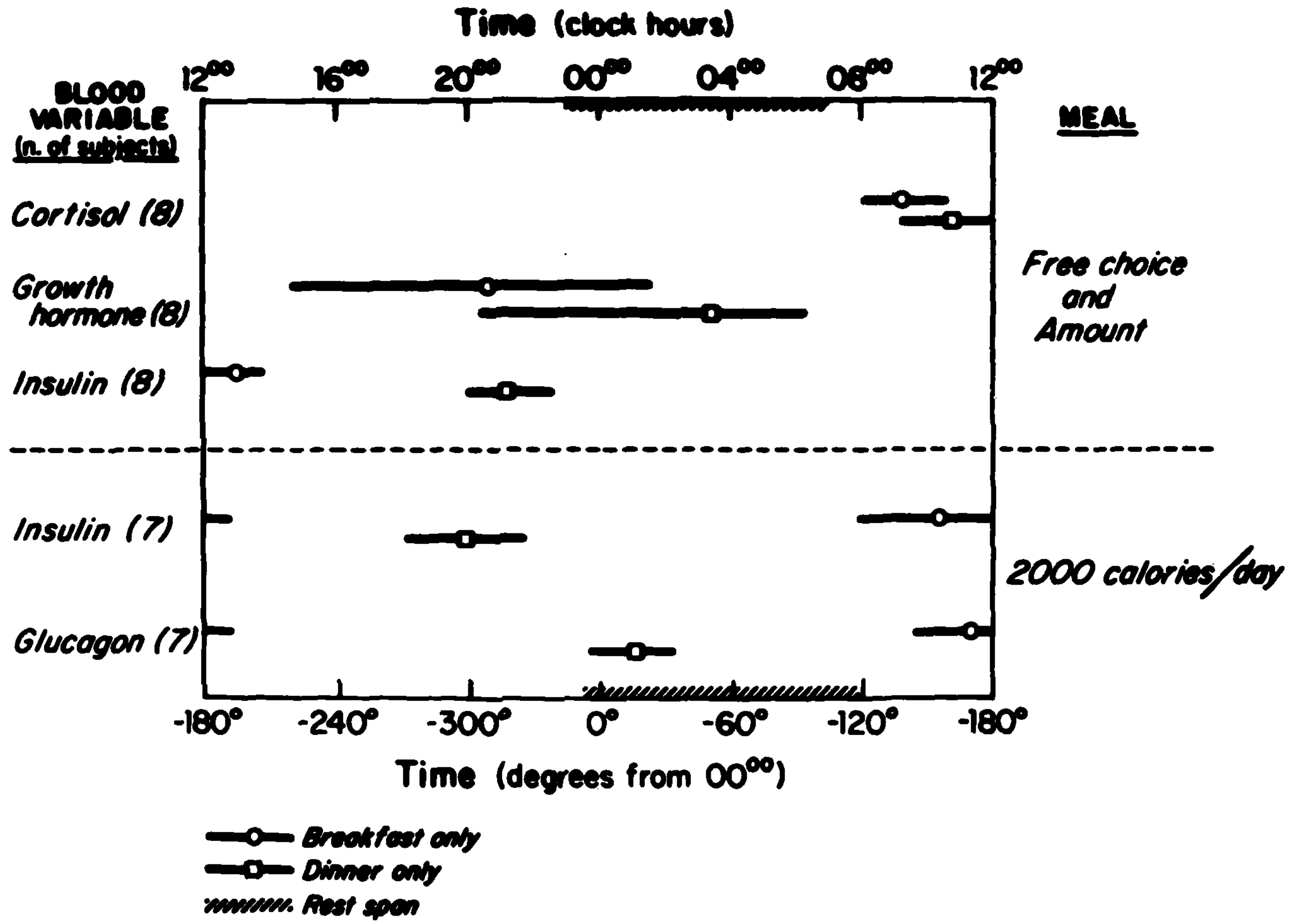
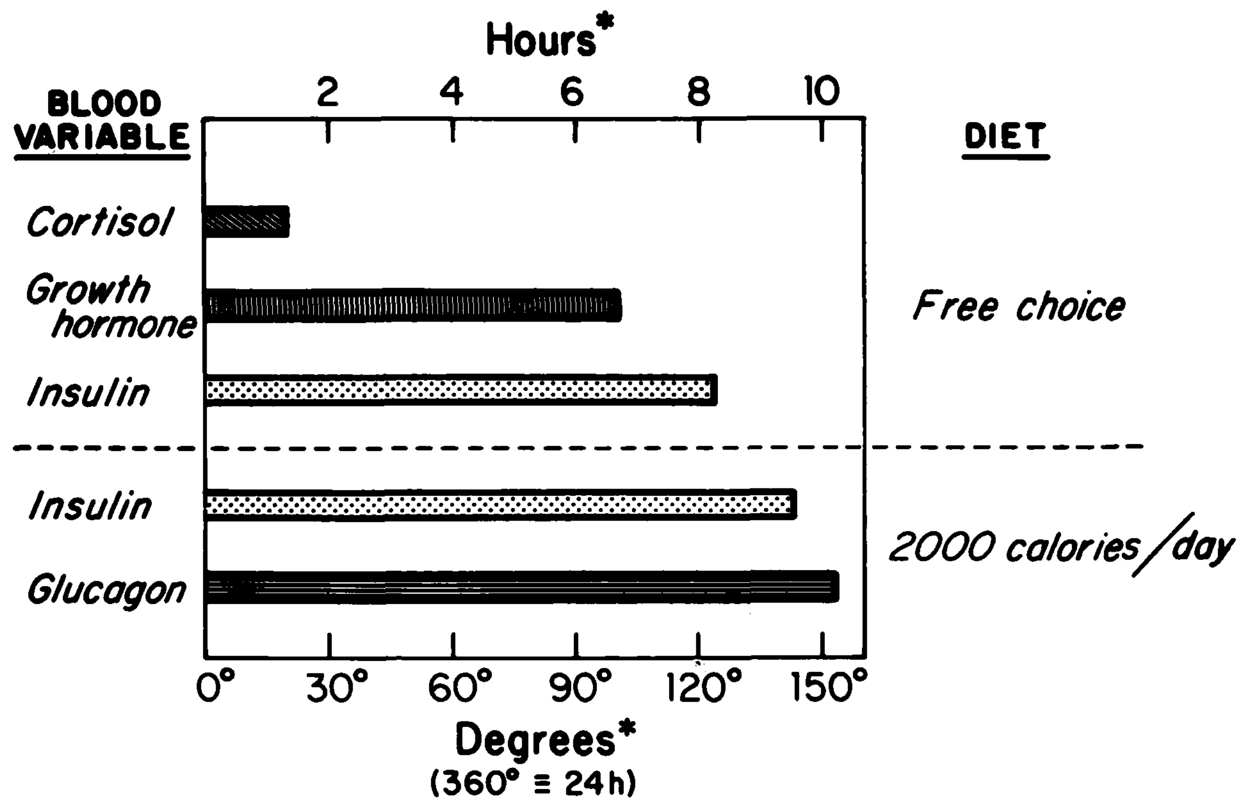


FIGURE 38

Differential Displacement* of Circadian Hormonal Timing as a Result of Changing a Single Daily Meal from Breakfast to Dinner



*Displacement of circadian acrophase on "dinner only" regimen (from value on "breakfast only" regimen)

The potential importance of the differential effect of mealtiming on these circadian hormonal rhythms should not be underestimated. It suggests that food may be utilized differently depending on the time of consumption. If this is true, it would be possible to optimize food utilization by manipulating mealtiming. The findings to be presented in the next section demonstrate the final outcome of such a manipulation.

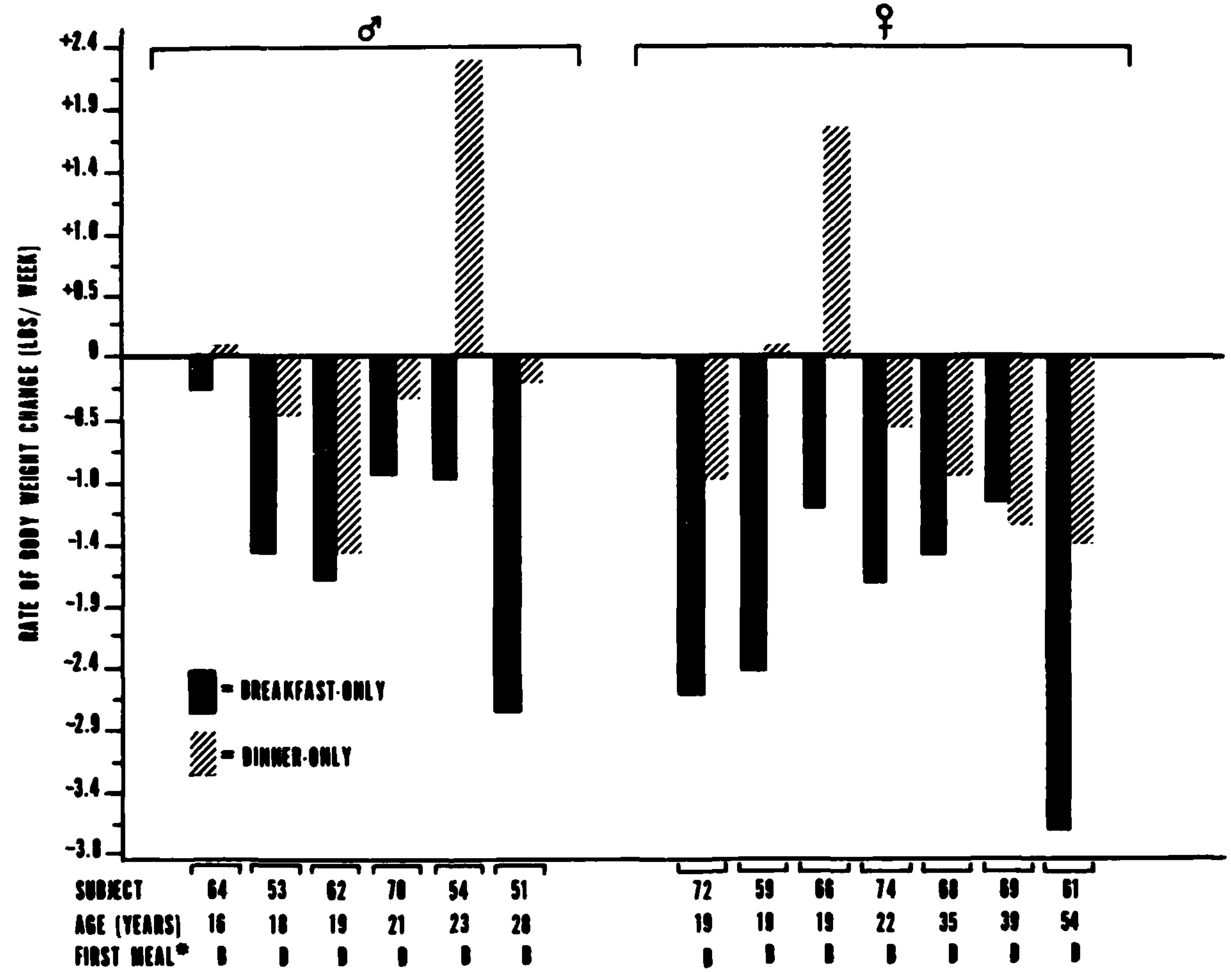
Changes in body weight. As might be expected, most subjects lost weight on the single daily meal regimen, especially during the first three-week span. However, subjects lost more weight while on Breakfast-only than on Dinner-only. Figure 39 summarizes these data for the Minnesota subjects who weighed themselves several times each day. Each individual's weight data were analyzed by the concomitant least-squares fit of both a cosine function and a trend component for each condition of mealtiming. The slopes of the fitted linear regressions are plotted for each subject including Subject No. 74 who was added after completion of the main portion of the study. The results show that relative weight loss was greater under the Breakfast-only condition for all participants except for Subject No. 69. This finding can be seen more clearly in Figure 40 where the actual differences in rate of weight change are plotted.

The body weight changes for all subjects are shown in Figures 41 to 43 according to the stage of the experiment. These are based on the first weights taken each day before the first meal. The changes represent the difference in body weight on the last day of each stage in comparison to that on the first day of that stage. More detailed weight data are presented in Appendix F–2 including the percentage of actual and excess weight lost. The first table of Appendix F–2 (F–2a) underscores the extensive differences among subjects' excess body weight before mealtime restriction. Some were as much as forty percent overweight at the end of Stage IV while others were substantially underweight. These differences should be kept in mind when interpreting the extent of weight change observed during Breakfast-only or Dinner-only. Larger or smaller changes might be expected with subjects selected for greater homogeniety of *ad libitum* excess body weight. Figure 41 illustrates the similarity of weight changes for the control and experimental subjects under *ad libitum* eating conditions during Stage IV. The individual numbers of pounds lost during the three weeks of Stages V and VI are shown in Figures 42 and 43. Again the phenomenon of greater relative weight loss on Breakfast-only is clearly apparent. Also note in the high degree of body weight stability exhibited by the control subjects during the same time spans.

The effects of mealtiming on body weight changes would be meaningless if they were due solely to differences in caloric intake between the Breakfast-only and Dinner-only conditions. By having available the daily caloric intake for each subject (N-16), we were able to reanalyze the weight data using multiple regressions to statistically parcel out the amount of weight change variance due to mealtiming as opposed to that due to the number of calories consumed. The partitioning of variance showed that a total of 50.8% of the variance was explainable. Of this total amount, 22.4% was attributable to mealtiming while only 13.0% was due to differences in caloric consumption. Overlap between the two predictors accounted for 15.4% of the total variance.

FIGURE 39

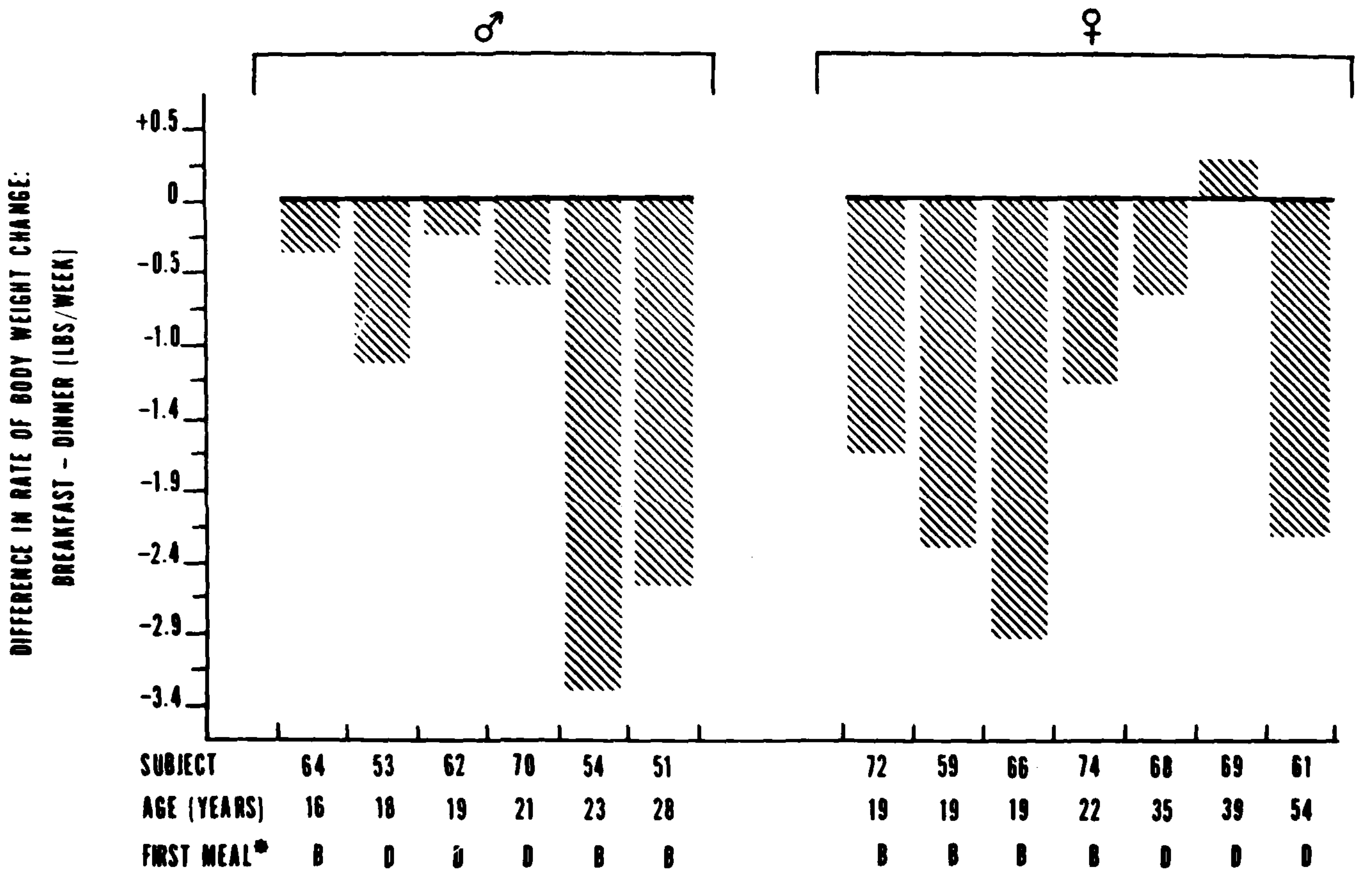
RATE OF BODY WEIGHT CHANGE IN SUBJECTS ON REGIMEN OF "BREAKFAST ONLY" OR "DINNER ONLY"



*HALF OF SUBJECTS FIRST ATE BREAKFAST-ONLY (B) WHILE OTHER HALF ATE DINNER-ONLY (D). AFTER 3 WEEKS, SUBJECTS SWITCHED TO OPPOSITE MEAL FOR THE NEXT 3 WEEKS. SUBJECT 74 WAS ON EACH SCHEDULE FOR 2 WEEKS.

FIGURE 40

DIFFERENCE IN WEEKLY BODY WEIGHT CHANGE IN SUBJECTS EATING "BREAKFAST-ONLY" VS. "DINNER-ONLY"



*HALF OF SUBJECTS FIRST ATE BREAKFAST-ONLY (B) WHILE OTHER HALF ATE DINNER-ONLY (D). AFTER 3 WEEKS, SUBJECTS SWITCHED TO OPPOSITE MEAL FOR THE NEXT 3 WEEKS. SUBJECT 74 WAS ON EACH SCHEDULE FOR 2 WEEKS.

FIGURE 41

INDIVIDUAL WEIGHT† CHANGES DURING STAGE IV
(NO MEALTIME RESTRICTIONS - 2 wks.)

WEIGHT CHANGE (lbs.)

+ 3	61	
2	70	
+ 1	06, 56, 64	
0	05, 51	NO CHANGE
- 1	04, 58, 63, 66, 69, 72	
2	02	
3	03, 62, 68, 70	
- 4 lb	53, 59	

† Based on body weight measures taken soon after awaking and before first meal.

FIGURE 42

INDIVIDUAL WEIGHT† CHANGES DURING STAGE V (3 wks.)

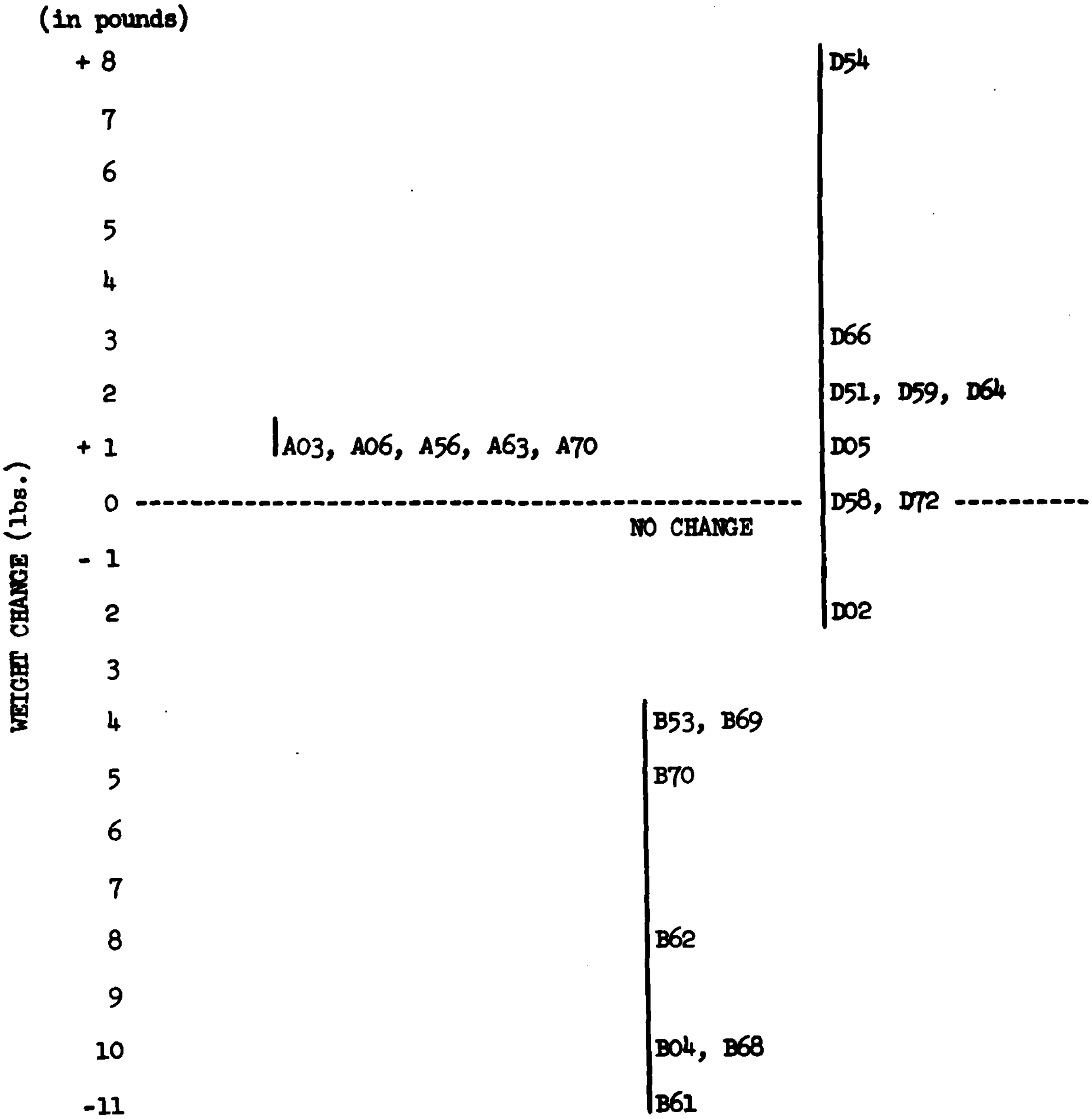
WEIGHT CHANGE (lbs.) (in pounds)			
+ 4	A63		
3			
2			
+ 1	A70		
0	A03		NO CHANGE
- 1	A06, A56	B58, B66	
2			D04
3		B54	D53, D68, D70
4		B02, B05, B64	D62
5			D61, D69
6			
7			
8			
9		B59	
10		B72	
11			
-12		B51	

<u>Key:</u>
- A No mealtime restrictions (Ad Lib)
- B Big breakfast only
- D Big dinner only

† Based on body weight measures taken soon after awaking and before first meal.

FIGURE 43

INDIVIDUAL WEIGHT† CHANGES DURING STAGE VI (3 wks.)



Key: A No mealtime restrictions (Ad Lib)
B Big breakfast only
D Big dinner only

† Based on body weight measures taken soon after awaking and before first meal.

Thus, it appears that the timing of a meal may be more important than its size in determining concomitant alterations in body weight. Although the precise physiological explanation of this phenomenon is still forthcoming, the results of the preceding section suggest that the metabolic fate of a meal depends somewhat on the current circadian state (i.e., concentration) of the circulating hormones which affect its digestion and assimilation. Because the acrophases of these hormonal rhythms are shifted differentially by restricted mealtiming, there are substantial differences in the biochemical environment which nutrients enter depending upon when they are consumed. These differences could reasonably be expected to affect nutrient processing and utilization and thereby result in different changes in body weight. However, before any further conclusions can be made about an explanatory mechanism, additional experiments must be undertaken to rule out any possible contribution to differential weight loss by systematic alterations in daily activity levels, i.e., caloric output, resulting from eating Dinner-only or Breakfast-only.

The present results can be compared with those from a similar, less extensive study conducted previously at the University of Minnesota in which all meals had a fixed number and kind of calories (Goetz, et al., 1976; Hirsch, et al., 1975).[43,66] Again, body weight loss was much greater on Breakfast-only compared to Dinner-only even though subjects ate the same amount at both mealtimes. Despite originally similar body weights for both sets of subjects, relative weight loss per week on Breakfast-only was greater in absolute terms for those in the earlier study. On the basis of caloric intake alone, this difference should be in the opposite direction since the present subjects ate a daily average of 1713 kcal while on Breakfast-only, and 2139 kcal on Dinner-only, as compared to the fixed 2000 kcal daily intake of the subjects in the earlier study. The explanation of this difference in weight loss may lie in the degree of free-choice permitted subjects in selecting their food. The fixed-calorie volunteers were required to alternately eat the same two dietician-prepared menus every other day, whereas the present subjects were always given a free choice among the twenty different meals. Thus, we may speculate that body weight loss can be affected by whether or not one likes the food consumed. A follow-up to this food preference, or forced-feeding, aspect of the two sets of results might be worthwhile.

Conclusions

1. Restricted mealtiming produced the following effects on the circadian rhythms self-measured by the subjects:

a. **Oral temperature.** The group acrophase was shifted slightly (about 1-hour) toward the time of the single daily meal, but there were large individual differences indicating that some subjects can be shifted more easily than others. Some of these differences may be due to differences in the subjects' *ad libitum* eating patterns which would result in greater or lesser shifts in mealtiming when switched to the single daily meal schedule employed here.

b. **Pulse.** The group acrophase was substantially shifted (4 to 5 hours) toward the time of the single daily meal. Moveover, this effect was seen in the data of almost every subject under both the Dinner-only and Breakfast-only conditions.

c. **Diastolic blood pressure.** The group acrophase was shifted from its usual time (about 13 hours after midsleep) in a direction away from the time of the single daily meal. This shift was greater under the Breakfast-only condition (3 hours) than under Dinner only (1 hour).

d. **Systolic blood pressure.** Restricted mealtiming increased the variability of this measure making the presence of a circadian rhythm doubtful compared to the clearly detectable circadian rhythm when mealtiming was not restricted.

e. **Mood.** Although the variability of mood ratings increased slightly with restricted mealtiming, the presence of a circadian rhythm continued with about the same acrophase as that seen under *ad libitum* mealtiming conditions.

f. ***Vigor.*** *Vigor ratings were* less erratic than the mood ratings under all conditions, manifesting a well-defined circadian rhythm which did not shift in phase when the subjects were switched to single daily meals.

2. Restricted mealtiming did not significantly shift the group's circadian rhythms for task performance. This lack of effect may well have been due to the relatively undemanding nature of the tasks which were used and the corresponding absence of a significant circadian rhythm in many of the subjects even under *ad libitum* mealtimes. The major results for each task are as follows:

a. **Reciprocal tapping.** There was a clear circadian rhythm for the group under all mealtime conditions, but this group rhythm was due to the contribution of slightly more than half the subjects who consistently manifested daily cyclicity on this task.

b. ***Finger counting.*** The findings for this task mimicked those for tapping except that the acrophase for performance occurred about an hour later in the day (about 12.5 hours after midsleep) than for tapping.

c. **Random number addition.** Again there were clear group circadian rhythms under each condition, and the acrophases were about the same as those for finger counting except for a slight (1-hour) shift towards later in the day under the Dinner-only condition. The same subjects who demonstrated significant circadian rhythms on the prior two tasks tended also to be the ones demonstrating them on this task.

d. **Grip strength.** The circadian rhythms for both left and right hand grip strength were almost identical in amplitude and phase, peaking at about the same time as performance on the previous two tasks; however, a much higher percentage of the individual subjects exhibited significant circadian rhythms than on any other performance task.

3. There were substantial shifts in the circadian rhythms of blood constituents following changes in mealtiming; however, the direction and extent of shift differed for each constituent in the following manner:

a. **White blood cells.** Restricted mealtiming shifted the acrophase from its usual occurrence just before lights-off to a time 2-hours earlier (Breakfast-only) or 2 hours later Ddinner-only).

b. **Lymphocytes.** Single daily meals produced a slight (1-hour) shift in the acrophase of this rhythm in the same direction as that for white blood cells; however, the relatively small number of subjects and extent of error variance involved in this measure precludes any statement about the reliability of the shift.

c. **Serum iron.** The acrophase was shifted greatly from its usual late morning occurrence to times corresponding to the eating of the single daily meal.

d. **Blood chloride.** The acrophase for this electrolyte usually occurred near the end of the daily dark span, but under restricted mealtime conditions it shifted slightly towards the time of the single meal.

e. **Blood urea nitrogen (BUN).** There was a ninety-degree (6-hours) shift in the acrophase from its usual occurrence just before the dark span in a direction away from the time of the single daily meal such that BUN peaked about 8 hours after the respective meal.

f. **Cortisol.** The effect of restricted mealtiming on the circadian rhythm for cortisol was unusual in that the acrophase was shifted only under the Dinner-only condition. The acrophases during the regimens of unrestricted mealtimes and Breakfast-only were identical, occurring about 1.5 hours after waking, while that for Dinner-only was shifted to 1.5 hours later in the day.

g. **Insulin.** As expected, the acrophase for insulin shifted toward the times of the single daily meals. Since this rhythm peaked in the late afternoon during unrestricted eating, there was less of a shift involved in switching to Dinner-only than to Breakfast-only.

h. **Somatotrophic hormone (STH).** The group acrophase for this rhythm occurred about 2 hours after lights-off during unrestricted mealtimes. Although there was substantial variability in the data for single daily meals, the acrophase for Breakfast-only was shifted to 5.5 hours earlier in the day while, that for Dinner-only did not shift from the *ad libitum* time.

4. Changes in **body weight** accompanied the eating of single daily meals. Subjects ate less and lost more weight on Breakfast-only than on Dinner-only, but this differential loss of weight was due more to the restricted timing of meals than to the decrease in

the number of calories eaten. Thus, in this experiment, mealtiming was more important than mealsize in determining changes in body weight. The explanation of such a finding may lie in the differential shifts (induced by the schedule of single daily meals) in the circadian rhythms of hormones involved in nutrient metabolism and calorie utilization.

5. Overall, the results of the biorhythm portion of the experiment indicate that mealtiming serves as an important synchronizer of human circadian rhythms and that substantial changes in mealtiming can alter the timing of many internal bodily rhythms. The observed differences in alteration demonstrate that it is possible to separate various hormonal and other physiological rhythms by manipulating mealtiming. Such changes in internal rhythms may correspondingly alter the timing of a person's daily capacity for peak performance, but the self-measurement tasks used here were probably not challenging enough to reveal any induced performance shifts if they occurred. The results related to body weight confirm those of an earlier experiment using fixed 2,000 kcal meals and indicate that calories eaten in the morning just after awakening may result in less weight gain than equivalent amounts eaten in the evening. Given that the metabolic fate of a meal differs at different circadian mealtimes, it should be possible to produce further gains or losses of weight by manipulating mealtimes as well as the number of calories a person eats. This finding has far-reaching implications for optimizing food utilization in programs ranging from diet therapy to international nutrition.

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Appendix A. Subject Information

1. Sequence of preference tests in relation to meals and rations for individual subjects.

2. Scheme of stages in study of mealtiming.

3. Volunteer subject consent form.

4. General instructions.

Table A-1. Sequence of Preference Tests in Relation to Meals and Rations for Individual Subjects

ID No	AD LIBITUM									RESTRICTED			
	Tests	STAGE I	Tests	STAGE II	Tests	STAGE III	Tests	STAGE IV	Tests	STAGE V	Tests	STAGE VI	Tests
1	1	P	4	F		C	10 12	F + C		D	18 19	B	20 21 17
3	1 2 P 3	"	4 6 F 8	"	5 C 7	"		"		A		A	
4		"	4 6 F 8	"	5 C 7	"		"		D		B	
2		"	4 5 C 7	C	6 F 8	F	9 11	"		B		D	
5		"		"		"		"		B		D	
6		"		"		"		"		A		A	
51	1 2 P 3	"	4 6 F 8	F	10 5 C 7	C	12	(")	(15 16)17	B	18 19	D	20 21 22
54		"		"		"		(")	(15 16)17	B	18 19	D	20 21 22
57		"		"		"		"	15 16 –	D	– –	B	20 21 17
59		"		"		"		(")	(15 16)17	B	18 19	D	20 21 22
61		"		"		"		(")		D		B	
62		"		"		"		(")		D		B	
53		"	4 5 C 7	C	9 6 F 8	F	11	(")		D	18 19	B	20 21 22
55		"		"		"		"	15 16 17				
56		"		"		"		(")	(15 16)17	A	– –	A	20 21 22
58		"		"		"		"	15 16 –	B	– –	D	20 21 17
63	1 2 P 3	"	4 5 C 7	"	9 6 F 8	"		C	15 16 –	A	– –	A	20 – 17
64	1		5	"	9 6 F 8	"		(F + C)	(15 16)17	B	18 19	D	20 21 22
65	1		5 C 7		6 F 8					A L+D D		B+L B A	20 21 17
66	1		5 C 7		6 F 8					A B+L B		L+D D A	20 21 17
66	Subject began this sequence after stage VI above.							F + C	15 16	B	18 19	D	20 21 22
68	1		5 C 7		6 F 8			"		D		B	20 21 17
69	1		5 C 7		6 F 8			"		D		B	
70†	1		5 C 7		6 F 8			"		A		A	
72	1		5		6			"		B		D	
73	1		5		6			"		A		A	

†Repeated Stages V and VI as D and B respectively with corresponding SPS's.

Legend for Table A–1.

Foods:

P = LRP Ration
F = Frozen Ration
C = MCI Ration
Underlining indicates smorgasbord of ration.

Meals:

A = Ad libitum
B = Breakfast-only
D = Dinner-only
L = Lunch

Preference Tests:

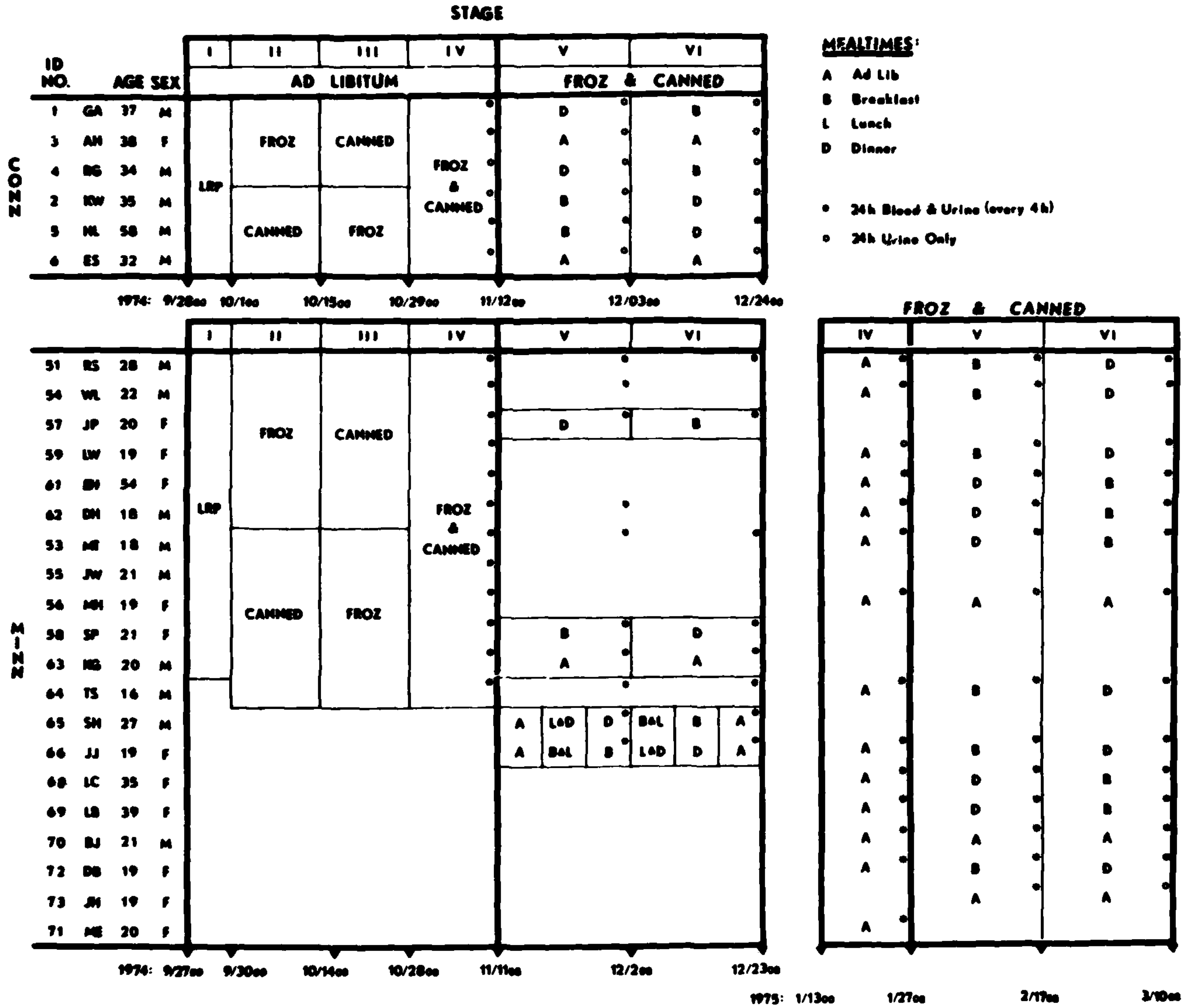
1 – 1st GPS
2 – LRP SPS before LRP smorgasbord
3 – LRP SPS after LRP smorgasbord
4 – LRP SPS after Stage I
5 – MCI SPS before MCI smorgasbord
6 – FROZ SPS before FROZ smorgasbord
7 – MCI SPS after MCI smorgasbord
8 – FROZ SPS after FROZ smorgasbord
9 – MCI SPS after Stage II
10 – FROZ SPS after Stage II
11 – FROZ SPS after Stage III
12 – MCI SPS after Stage III
15 – MCI SPS after Stage IV
16 – FROZ SPS after Stage IV
17 – 2nd GPS
18 – MCI SPS after Stage V
19 – FROZ SPS after Stage V
20 – MCI SPS after Stage VI
21 – FROZ SPS after Stage VI
22 – 3rd GPS

( ) – enclosed diet or SPS repeated before Stage V.

APPENDIX A–2

FIGURE A–2

SCHEME OF STAGES IN STUDY OF MEAL TIMING



APPENDIX A–3

VOLUNTEER SUBJECT CONSENT FORM

Of my own free will I volunteer to participate in chronobiologic studies to investigate rhythms in physiological functions. I consent to the use of data collected by me or on me for purposes of scientific publication, but I understand that my name will not be disclosed in relation to such data unless I give written and witnessed permission to do so.

All investigative procedures (as described in the Physiology Teacher 1:1–11, 1972) that I shall be concerned with have been fully explained to me and to my satisfaction, including any possible risks, and I have fully understood these explanations. All questions I have about these procedures have been answered to my satisfaction.

I realize that repeated blood withdrawal involves entering a vein and that such procedures may have untoward effects. These effects have been thoroughly explained to me. I will be carefully attended to determine and treat (at no cost) any untoward reactions that may result from the research procedures.

I agree to undertake the study as described to me with the understanding that I may withdraw my consent and discontinue participation at any time without prejudice.

______________________________ (signature of volunteer)

____________________ (date)

______________________________ (signature of parent or legal gardian)

____________________ (date)

______________________________ (witnessed)

____________________ (date)

APPENDIX A–4

GENERAL INSTRUCTIONS

24 Sept 74

Please Read Carefully and **Save** for Future Reference

During the next 13 weeks you may wish to participate as a volunteer student and, if you also desire, as a coinvestigator in a cooperative study between the U.S. Army Natick Laboratories, New Britain General Hospital, Connecticut, and the Chronobiology Laboratories at the University of Minnesota, Department of Laboratory Medicine and Pathology, Minneapolis, Minnesota. The general purposes of this project will be communicated to you in the second part of the study, but will not be known to you in the first part when you perform primarily the tasks of self-measurement, except that you know of course from the background of our laboratory that we are interested in chronobiologic problems in general and the optimization of meals, with special reference to mealtiming, in particular.

Throughout the study you will be provided different types of free military rations and will be expected to keep an accurate daily record of everything you eat and drink (except water). To do this you will be given a set of "Daily Food Logs" appropriate to the type of rations you are currently receiving. The instructions for completing these logs are attached. At the beginning of each ration phase you will be given two of each of the meals comprising that set of rations. Subsequently you will turn in (or mail if necessary) your previous day's food log and replenish your ration supply on a daily basis. If necessary, you may be allowed on some occasions to take home more than just the replenishment amount; however, even if you do not need to return to the lab for food on a given day, you should be certain to mail in your food log for the previous day. At the end of each ration phase, please turn in all excess food you may have stored at home. According to government regulations these foods may **only** be used for research purposes by subjects participating in the experiment.

The following specific instructions apply to the preparation and weighing of the different ration types:

Long-Range Patrol (LRP) Rations – For proper and complete rehydration these rations should be reconstituted by adding 13 oz. of hot water to the entree while in the plastic bag and waiting 5 minutes. If desired, you may then "dish out" some of the entree for consumption, especially if the meal appears too watery in the bag; however, be sure to return all entree leftovers and liquid to the plastic bag before weighing (weigh combined bag and leftovers). Please do **not** deviate from the 13 oz. amount of water in the preparation phase, since this will alter the palatability and confound the weighing measurements.

Meal Combat Individual (MCI) Rations – These meals may be eaten at room temperature or heated as desired. Please note on the food log whether or not they were heated. Leftovers should be weighed out of the containers.

Precooked Frozen Meal Rations – These meals should be heated in an oven for approximately 25 min. at 425° before serving. Weigh the leftovers out of the container.

For weighing purposes each of you will be provided with a dietetic scale which can be adjusted by a thumbscrew to compensate for the weight of any dish used to hold the leftovers. Make certain you report the leftover weights to the nearest gram so that we can obtain the most accurate measure possible of your daily caloric intake.

In addition to the provided rations you will be permitted to eat white bread or toast (no rye, whole wheat, etc.). You may drink the cocoa beverages provided as well as coffee, tea, low calorie milk (99% fat free), and low calorie soft drinks. These should be entered on the log as per instructions.

Throughout the experiment you should **feel free to break up** any meal pack and eat only what you want. For instance, when you are in the MCI ration phase you may want to take out and eat only the fruit can of a particular meal and save the rest for some other time. As long as all food consumption is recorded, this is perfectly reasonable. Of course, such meal breakdowns are not possible with the frozen meals due to storage difficulties; however, you should **always** feel free to eat only exactly **what** food and **how much** food you desire at that time. During the initial or **ad libitum** stage of the study you are also encouraged to eat **whenever** you wish and **as often** as you wish.

If at any time you are unable to adhere to the above guidelines for eating and drinking, be sure to note it accordingly on that day's food log by including the name, time, and amount of whatever else you may have consumed (use back of log sheet if necessary). If you have any questions during any part of the study please feel free to call me collect (617–653–1000 Ext. 2148) or be sure to contact the monitor of the experiment at your location.

Thank You For Your Cooperation

Curt Graeber, Ph.D.
CPT, USA
Natick Laboratories

Appendix B. Food Preference Surveys

1. U.S. Army Natick Labs 1972 food preference survey.
2. Food items dropped from analysis of NLABS general food preference survey.
3. Instructions for ration-specific food preference surveys.
4. Meal Combat Individual food preference survey.
5. Precooked Frozen Meal food preference survey.
6. Canned food menu questionnaire.
7. Frozen food menu questionnaire.

APPENDIX B–1

FOOD PREFERENCE SURVEY

U. S. ARMY NATICK LABORATORIES

NOVEMBER 1972

Booklet Serial Number

In the grid to your right, please fill in the ovals corresponding with the Booklet Serial Number that is stamped directly above the numeric grid.

0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Food Preference Survey
Background Information

Instructions for all questions: For each question completely fill in the circle around the number of your answer.

INSTALLATION CODE (To be supplied by testers.)

⓪①②③④⑤⑥⑦⑧⑨

DINING FACILITY CODE (To be supplied by testers.)

⓪①②③④⑤⑥⑦⑧⑨

Fill in the appropriate circles which indicate your AGE at last birthday.

1st digit ⓪①②③④⑤⑥⑦⑧⑨

2nd digit ⓪①②③④⑤⑥⑦⑧⑨

Fill in the circle which indicates your RACE.
- ○ Caucasian
- ○ Negro
- ○ Oriental
- ○ Other (specify__________________)

Fill in the circle which indicates your SEX.
- ○ Male
- ○ Female

Fill in the circle which indicates your HIGHEST LEVEL OF EDUCATION.
- ○ Some Grade School
- ○ Finished Grade School
- ○ Some High School
- ○ High School Graduate (includes GED)
- ○ Skilled Job Training
- ○ Some College
- ○ College Graduate
- ○ Beyond College

What is your WEIGHT in pounds?

1st digit ⓪①②③④⑤⑥⑦⑧⑨
2nd digit ⓪①②③④⑤⑥⑦⑧⑨
3rd digit ⓪①②③④⑤⑥⑦⑧⑨

What is your HEIGHT?

Feet ⓪①②③④⑤⑥⑦⑧⑨
Inches ⓪①②③④⑤⑥⑦⑧⑨⑩⑪

Where were you raised? Fill in the appropriate circle.

- ○ In the country
- ○ In a town with less than 2,500 people
- ○ In a town or small city with more than 2,500, but less than 25,000 people
- ○ In a city with more than 25,000, but less than 100,000 people
- ○ In a large city with more than 100,000, but less than one million people
- ○ In a very large city with over one million people
- ○ In a suburb of a large or very large city

In what STATE were you raised? Fill in the appropriate circle.

- ○ 01 Alabama
- ○ 02 Alaska
- ○ 03 Arizona
- ○ 04 Arkansas
- ○ 05 California
- ○ 06 Colorado
- ○ 07 Connecticut
- ○ 08 Delaware
- ○ 09 Florida
- ○ 10 Georgia
- ○ 11 Hawaii
- ○ 12 Idaho
- ○ 13 Illinois
- ○ 14 Indiana
- ○ 15 Iowa
- ○ 16 Kansas
- ○ 17 Kentucky
- ○ 18 Louisiana
- ○ 19 Maine
- ○ 20 Maryland
- ○ 21 Massachusetts
- ○ 22 Michigan
- ○ 23 Minnesota
- ○ 24 Mississippi
- ○ 25 Missouri
- ○ 26 Montana
- ○ 27 Nebraska
- ○ 28 Nevada
- ○ 29 New Hampshire
- ○ 30 New Jersey
- ○ 31 New Mexico
- ○ 32 New York
- ○ 33 North Carolina
- ○ 34 North Dakota
- ○ 35 Ohio
- ○ 36 Oklahoma
- ○ 37 Oregon
- ○ 38 Pennsylvania
- ○ 39 Rhode Island
- ○ 40 South Carolina
- ○ 41 South Dakota
- ○ 42 Tennessee
- ○ 43 Texas
- ○ 44 Utah
- ○ 45 Vermont
- ○ 46 Virginia
- ○ 47 Washington
- ○ 48 West Virginia
- ○ 49 Wisconsin
- ○ 50 Wyoming
- ○ 51 Other U.S. territories or possessions (For example, Puerto Rico or Virgin Islands.)
- ○ 52 Outside the U.S. or U.S. Territories or possessions.

What ONE TYPE OF COOKING were you raised on? Fill in the appropriate circle.

- ○ 01 Chinese
- ○ 02 English
- ○ 03 French
- ○ 04 General American Style
- ○ 05 German
- ○ 06 Greek
- ○ 07 Italian
- ○ 08 Japanese
- ○ 09 Jewish
- ○ 10 Mexican
- ○ 11 New England
- ○ 12 Polish (& Eastern Europe)
- ○ 13 Soul
- ○ 14 Southern
- ○ 15 Spanish (not Mexican)
- ○ 16 Other (please specify ________________)

What TYPE OF COOKING OR SPECIALTY FOODS do you like best? Please fill in the circles of your TOP THREE CHOICES.

- ○ 01 Chinese
- ○ 02 English
- ○ 03 French
- ○ 04 General American Style
- ○ 05 German
- ○ 06 Greek
- ○ 07 Italian
- ○ 08 Japanese
- ○ 09 Jewish
- ○ 10 Mexican
- ○ 11 New England
- ○ 12 Polish (& Eastern Europe)
- ○ 13 Soul
- ○ 14 Southern
- ○ 15 Spanish (not Mexican)
- ○ 16 Seafood
- ○ 17 Other (please specify ________________)

Food Preference Survey

Instructions

Your answers to the following questions will help the Armed Forces Menu Planners put foods which you want on the menu. This is not a test. We are interested in *your opinion* so please do not check your answers with your friends.

On the following pages, please indicate HOW MUCH YOU LIKE OR DISLIKE each food and HOW OFTEN YOU WANT TO EAT the food. If you have never tried the food item or have never heard of it, fill in the circle in the first column labelled NEVER TRIED and leave the rest of the line blank.

If you are familiar with a food on the list and would like to eat it, you should fill in a circle in the column 'Like or Dislike'. In order to say how much you like or dislike a food, look at the following scale.

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

Notice that the rating of 5 is neutral, meaning that you neither like nor dislike the food. Ratings below 5 indicate dislike, while ratings above 5 indicate like. Fill in the circle of the number which best describes your feelings for the particular food item. Remember to mark every food item except the ones which you have never tried.

Example:

If you like Danish Pastry very much, you would fill in:

①②③④⑤⑥⑦●⑨

If you dislike it slightly, you would fill in:

①②③●⑤⑥⑦⑧⑨

After rating HOW MUCH YOU LIKE OR DISLIKE THE FOOD, continue across the same line to the last two columns labelled 'How Often You Want To Eat The Food'. Decide how many days per month you would like to eat the food. If you want a food 3 meals or more on the same day, it should still be counted as one day. For any number of days from 01 to 30, fill in two circles, one in each column. If you never want the food, fill in the two zeros, one in each column.

Please note the following examples:

Example 1

If you would like to eat a food 18 days per month, you would mark,

⓪●②③ | ⓪①②③④⑤⑥⑦●⑨

As you can see, the number you chose (18) has been filled in, one digit per column. You should fill in only one circle per column, but both columns must have one circle filled.

Example 2

If you would like a food only once a month, fill in 01.

●①②③ | ⓪●②③④⑤⑥⑦⑧⑨

In this example, the number you chose (1) has only one digit. In this case, you fill in the 0 in the left column and fill in the 1 in the right column.

If you do not want the food at all, you should mark the zero in each column.

This is not a survey of how much you like foods served in the Armed Forces. We are interested in how much you like these foods in general. Think of the food in a general way, rather than any particular time you have eaten it.

Remember, if you are not familiar with the food item, mark the first column labelled NEVER TRIED and leave the other columns blank. If you are familiar with the item, then first rate HOW MUCH YOU LIKE OR DISLIKE THE FOOD and then indicate HOW OFTEN YOU WANT TO EAT THE FOOD.

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

	NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)	
001 Honeydew Melon	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
002 Vealburger	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
003 Tea	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
004 Chili Macaroni	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
005 Barbecued Beef Cubes	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
006 Roast Turkey	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
007 Blueberry Muffins	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
008 Strawberry Shortcake	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
009 Baking-Powder Biscuits	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
010 Grape Juice	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
011 Nut Bars	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
012 Turnip Greens	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
013 Celery & Carrot Sticks	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
014 Boiled Pigs' Feet	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
015 Grilled Minute Steak	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
016 Hot Turkey Sandwich with Gravy	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
017 Sliced Tomato Salad	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
018 Braised Liver with Onions	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
019 Tomato Juice	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
020 Creamed Frozen Peas	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
021 Mashed Rutabagas (Turnip)	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
022 Fried Rice	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
023 Corned Beef	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
024 French Fried Carrots	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
025 Egg Drop Soup	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
026 Jellied Fruit Salad	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
027 Apricot Pie	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
028 Gingerbread	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
029 Cheeseburger	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
030 Apple Juice	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
031 Sausage Links	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
032 Banana Cake	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
033 Turkey Club Sandwich	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
034 Pineapple Upside Down Cake	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
035 Frozen Lima Beans	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
036 Grilled Bologna	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
037 Oatmeal Cookies	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
038 Skimmed Milk	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
039 Pork Sausage Patties	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
040 Italian Dressing	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
041 Baked Fish	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
042 Hot Reuben Sandwich	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
043 French Toast	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
044 Pizza	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
045 Shrimp Creole	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
046 Caesar Dressing	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
047 Split Pea Soup	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
048 Pepper Soda	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
049 Ice Cream	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
050 Simmered Sauerkraut	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
051 Steamed Rice	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
052 Buttered Noodles	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
053 Raspberry Shortcake	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
054 Swiss Steak	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

	NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)	
055 Hot Fudge Sundae	O	123456789	0123	0123456789
056 Canned Green Beans	O	123456789	0123	0123456789
057 Breaded Veal Steaks	O	123456789	0123	0123456789
058 Chitterlings	O	123456789	0123	0123456789
059 Pork Chop Suey	O	123456789	0123	0123456789
060 Lemon Cookies	O	123456789	0123	0123456789
061 Lasagna	O	123456789	0123	0123456789
062 Hamburger	O	123456789	0123	0123456789
063 Fish Chowder	O	123456789	0123	0123456789
064 Corned Beef Hash	O	123456789	0123	0123456789
065 Scrapple	O	123456789	0123	0123456789
066 Hot Pastrami Sandwich	O	123456789	0123	0123456789
067 Rice Pudding	O	123456789	0123	0123456789
068 Apple Crisp	O	123456789	0123	0123456789
069 French Fried Fish Sticks	O	123456789	0123	0123456789
070 Yellow Cake	O	123456789	0123	0123456789
071 Fruit Bars	O	123456789	0123	0123456789
072 Ravioli	O	123456789	0123	0123456789
073 Tossed Green Salad	O	123456789	0123	0123456789
074 Baked Tuna & Noodles	O	123456789	0123	0123456789
075 Baked Yellow Squash	O	123456789	0123	0123456789
076 Sausage Stuffing	O	123456789	0123	0123456789
077 Angel Food Cake	O	123456789	0123	0123456789
078 Hot Potato Salad	O	123456789	0123	0123456789
079 French Fried Cauliflower	O	123456789	0123	0123456789
080 Pears (canned)	O	123456789	0123	0123456789
081 Devilled Eggs	O	123456789	0123	0123456789
082 Veal Parmesan	O	123456789	0123	0123456789
083 Peach Shortcake	O	123456789	0123	0123456789
084 Stuffed Green Peppers	O	123456789	0123	0123456789
085 Polish Sausage	O	123456789	0123	0123456789
086 Peach Pie	O	123456789	0123	0123456789
087 Sugar Cookies	O	123456789	0123	0123456789
088 Fried Chicken	O	123456789	0123	0123456789
089 Tomato Vegetable Noodle Soup	O	123456789	0123	0123456789
090 Fruit Cup	O	123456789	0123	0123456789
091 Sweet Potatoes	O	123456789	0123	0123456789
092 English Muffins	O	123456789	0123	0123456789
093 Carrot, Raisin & Celery Salad	O	123456789	0123	0123456789
094 Fried Parsnips	O	123456789	0123	0123456789
095 Vanilla Wafers	O	123456789	0123	0123456789
096 Stuffed Cabbage	O	123456789	0123	0123456789
097 Sauerbraten	O	123456789	0123	0123456789
098 Enchiladas	O	123456789	0123	0123456789
099 Butterscotch Sundae	O	123456789	0123	0123456789
100 Sour Cream Dressing	O	123456789	0123	0123456789
101 Vegetable Juice	O	123456789	0123	0123456789
102 Peaches (fresh)	O	123456789	0123	0123456789
103 Thousand Island Dressing	O	123456789	0123	0123456789
104 French Fried Scallops	O	123456789	0123	0123456789
105 Beer	O	123456789	0123	0123456789
106 Lemon-Lime Soda	O	123456789	0123	0123456789
107 Frozen Green Beans	O	123456789	0123	0123456789
108 Raisin Cookies	O	123456789	0123	0123456789
109 Hashed Brown Potatoes	O	123456789	0123	0123456789

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

	NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)
110 Cabbage			
111 Sweet Rolls			
112 Spinach			
113 Cream of Mushroom Soup			
114 Savory Bread Stuffing			
115 Chef's Salad			
116 Bean Soup			
117 Banana Cream Pie			
118 Lime-flavored Drink			
119 Sweet Potato Pie			
120 Pineapple Sundae			
121 Lettuce Salad			
122 Buttered Carrots			
123 Low-Calorie Soda			
124 Cola			
125 Roast Lamb			
126 Buttermilk			
127 Cream of Potato Soup			
128 Grapefruit-Orange Juice			
129 Fried Oysters			
130 Pork and Beans			
131 Orange Soda			
132 Strawberry Chiffon Pie			
133 Spaghetti with Meat Sauce			
134 Ham			
135 Refried Beans			
136 Baked Bean Sandwich			
137 Braised Trake			
138 Bananas			
139 Milk Shake			
140 Canned Green Beans			
141 Apples (fresh)			
142 Swedish Meatballs			
143 Peanut Butter Cake			
144 Chocolate Cream Pie			
145 Frijole Salad			
146 Burritos			
147 Chocolate Cookies			
148 Sweet & Sour Pork			
149 Rice Pilaf			
150 Fresh Coffee			
151 Buttered Mixed Vegetables			
152 Beef Stew			
153 Guacamole Dip			
154 Banana Cream Pudding			
155 Meatball Submarine			
156 Boston Baked Beans			
157 Roast Pork			
158 Devil's Food Cake			
159 Chili Con Carne			
160 Salisbury Steak			
161 Buttered Succotash			
162 Fried Cabbage			
163 Chocolate Cake Pudding			
164 Grapefruit Half (fresh)			

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

	NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)
165 Scalloped Potatoes	○		
166 Mustard Greens	○		
167 French Fried Shrimp	○		
168 Vegetable Soup	○		
169 Fruit Flavored Yogurt	○		
170 Tacos	○		
171 Pumpkin Pie	○		
172 Ham Sandwich	○		
173 Grilled Lamb Chops	○		
174 White Cake	○		
175 Tangerines	○		
176 Eggs to Order	○		
177 Peaches (canned)	○		
178 Boiled Navy Beans	○		
179 Submarine Sandwich	○		
180 Kidney Bean Salad	○		
181 Butterscotch Brownies	○		
182 Grapefruit-Pineapple Juice	○		
183 Stewed Tomatoes	○		
184 Sukiyaki	○		
185 Strawberry Gelatin	○		
186 Canned Peas	○		
187 Lemonade	○		
188 Italian Sausage	○		
189 Macaroni Salad	○		
190 Beef Stroganoff	○		
191 Fried Okra	○		
192 Pot Roast	○		
193 Grilled Ham & Cheese Sandwich	○		
194 Pepper Steak	○		
195 Pickled Beet & Onion Salad	○		
196 Plain Muffins	○		
197 Fried Pie (Fruit)	○		
198 Corn Fritters	○		
199 Pound Cake	○		
200 Lemon Meringue Pie	○		
201 Boston Cream Pie	○		
202 Chocolate Milk	○		
203 Roast Beef	○		
204 French Fried Onion Rings	○		
205 Creamed Style Corn	○		
206 Chocolate Drop Cookies	○		
207 Frozen Peas	○		
208 Brussels Sprouts	○		
209 Gingerale	○		
210 Waldorf Salad (Apples, Celery & Raisin)	○		
211 Milk Shake	○		
212 Molasses Cookies	○		
213 Pineapple (canned)	○		
214 Marble Cake	○		
215 Baked Ham	○		
216 Lobster	○		
217 Hot Chocolate	○		
218 Canned Lima Beans	○		
219 Cold Potato Salad	○		

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

	NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)
220 Sloppy Joe			
221 Cheesecake			
222 Oranges			
223 Plums (fresh)			
224 Hot Oatmeal			
225 Grilled Cheese Sandwich			
226 Meat Loaf			
227 Ham			
228 Pears (fresh)			
229 Mixed Fruit Salad			
230 Creamed Onions			
231 Freeze-dried Coffee			
232 Coconut Raisin Cookies			
233 Chocolate Pudding			
234 Cantaloupe			
235 Salami Sandwich			
236 Omelet			
237 Corn Chowder			
238 Butterscotch Cream Pie			
239 Creamed Ground Beef			
240 Turkey Rice Soup			
241 Milk			
242 Buttered Wax Beans			
243 Spice Cake			
244 Asparagus			
245 Potato Chips			
246 Pineapple (canned)			
247 Coffee Cake			
248 Grape-flavored Drink			
249 Iced Tea			
250 Pizza			
251 Onion Soup			
252 Banana Split			
253 Spaghetti with Meatballs			
254 Grilled Ham			
255 Lemon Chiffon Pie			
256 Hot Roast Beef Sandwich with Gravy			
257 Chocolate Cream Cake			
258 Chicken Noodle Soup			
259 Sherbet			
260 French Dressing			
261 Applesauce			
262 Barbecued Spareribs			
263 Cucumber & Onion Salad			
264 Giblet Stuffing			
265 Pineapple Cheese Salad			
266 Buttered Ermal			
267 Fried Eggplant			
268 Tomato Soup			
269 Pineapple Cream Pie			
270 Buttered Peas & Carrots			
271 Pork Hocks			
272 Grapefruit Juice			
273 Pickled Pigs' Feet			
274 French Fried Potatoes			

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

	NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)	
275 Collard Greens	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
276 Vanilla Cream Pudding	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
277 Cherry Upside Down Cake	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
278 Canned Peas	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
279 Cherry Soda	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
280 Blackberry Pie	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
281 Blue Cheese Dressing	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
282 Figs (canned)	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
283 Corn Bread Stuffing	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
284 Salmon	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
285 Tossed Vegetable Salad	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
286 Waffles	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
287 Tuna Salad Sandwich	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
288 Grapefruit Sections (canned)	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
289 Baked Stuffed Pork Chops	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
290 Seafood Platter	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
291 Cherry Pie	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
292 Beef Barley Soup	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
293 Hot Tamales	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
294 Canadian Bacon	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
295 Roast Veal	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
296 Baked Potatoes	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
297 Danish Pastry	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
298 Nut Cookies	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
299 Ham Loaf	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
300 Chicken Cacciatore	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
301 Cornbread	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
302 Egg Salad Sandwich	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
303 Fishwich	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
304 Bacon	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
305 Plums (canned)	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
306 Bologna Sandwich	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
307 Grape Soda	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
308 Vinegar & Oil Dressing	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
309 Coconut Cream Pudding	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
310 Cole Slaw	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
311 Frankfurters	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
312 Grape Lemonade	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
313 Cottage Cheese & Fruit Salad	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
314 Orange-flavored Drink	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
315 Buttered Whole Kernel Corn	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
316 Western Sandwich	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
317 Broccoli	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
318 Pineapple Juice	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
319 Coconut Custard Pie	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
320 Fried Fish	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
321 Cold Cereal	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
322 Beef Rice Soup	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
323 Stewed Prunes (canned)	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
324 Corn-on-the-Cob	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
325 Blueberry Pie	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
326 Cranberry Juice	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
327 Sweet Cherries (canned)	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
328 Baked Chicken	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9
329 Garden Cottage Cheese Salad	○	1 2 3 4 5 6 7 8 9	0 1 2 3	0 1 2 3 4 5 6 7 8 9

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

		NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)
330	Baked Tuna & Noodles			
331	Raisin Pie			
332	Fruit Punch			
333	Peanut Butter and Jelly Sandwich			
334	Mashed Potatoes			
335	Creole Soup			
336	Soft Serve Ice Cream			
337	Cherry Cake Pudding			
338	Spanish Rice			
339	Funistrada			
340	Tomato Juice			
341	Buttered Zucchini Squash			
342	Spareribs with Sauerkraut			
343	Watermelon			
344	Creamed Chipped Beef			
345	Frankfurter, Cheese and Bacon			
346	Root Beer			
347	Turkey Pot Pie			
348	Grilled Steak			
349	Baked Macaroni & Cheese			
350	Pineapple Pie			
351	Minestrone Soup			
352	Banana Salad			
353	Fruit Cocktail (canned)			
354	Hot Whole Wheat Cereal			
355	Buttered Cauliflower			
356	Clam Chowder			
357	Jellied Vegetable Salad			
358	Bread Pudding			
359	Harvard Beets			
360	Bacon, Lettuce & Tomato Sandwich			
361	Lasagna			
362	Prune Juice			
363	Russian Dressing			
364	Doughnuts			
365	Brownies			
366	Oranges			
367	Apricots (canned)			
368	Butterscotch Pudding			
369	Sliced Orange Salad			
370	Strawberry Sundae			
371	Apple Pie			
372	Hominy Grits			
373	Cherry-flavored Drink			
374	Peanut Butter Cookies			
375	Orange Juice			
376	Grapes			
377	Griddle Cakes			
378	Instant Coffee			

Appendix B–2

Food Items Dropped from Analysis of: Armed Forces Food Preferences--Technical Report 75–63–FSL, December 1974.[94]

ID	NAME
155	Meatball Submarine
316	Western Sandwich
45	Shrimp Creole
98	Enchiladas
293	Hot Tamales
53	Raspberry Shortcake
303	Fishwich
300	Chicken Cacciatore
264	Giblet Stuffing
184	Sukiyaki
66	Hot Pastrami Sandwich
198	Corn Fritters
148	Sweet & Sour Pork
369	Sliced Orange Salad
197	Fried Pie (Fruit)
312	Grape Lemonade
238	Butterscotch Cream Pie
129	Fried Oysters
240	Turkey Rice Soup
337	Cherry Cake Pudding
269	Pineapple Cream Pie
153	Guacamole Dip
42	Hot Reuben Sandwich
356	Clam Chowder
363	Russian Dressing
114	Savory Bread Stuffing
292	Beef Barley Soup
143	Peanut Butter Cake
352	Banana Salad
275	Collard Greens
97	Sauerbraten
48	Pepper Soda
212	Molasses Cookies
181	Butterscotch Brownies
372	Hominy Grits
263	Cucumber & Onion Salad

ID	NAME
46	Caesar Dressing
149	Rice Pilaf
351	Minestrone Soup
145	Frijole Salad
271	Pork Hocks
210	Waldorf Salad
76	Sausage Stuffing
135	Refried Beans
11	Nut Bars
71	Fruit Bars
232	Coconut Raisin Cookies
119	Sweet Potato Pie
65	Scrapple
237	Corn Chowder
161	Buttered Succotash
63	Fish Chowder
339	Funistrada
191	Fried Okra
335	Creole Soup
329	Garden Cottage Cheese Salad
281	Blue Cheese Dressing
265	Pineapple Cheese Salad
166	Mustard Greens
267	Fried Eggplant
231	Freeze-Dried Coffee
162	Fried Cabbage
355	Buttered Cauliflower
273	Pickled Pigs Feet
357	Jellied Vegetable Salad
27	Apricot Pie
341	Buttered Zucchini Squash
359	Harvard Beets
169	Fruit Flavored Yogurt
100	Sour Cream Dressing
58	Chitterlings
266	Buttered Ermal
25	Egg Drop Soup
331	Raisin Pie
180	Kidney Bean Salad
195	Pickled Beet & Onion Salad

ID	NAME
137	Braised Trake
136	Baked Bean Sandwich
93	Carrot, Raisin & Celery Salad
282	Figs (Canned)
14	Boiled Pigs Feet
75	Baked Yellow Squash
230	Creamed Onions
79	French Fried Cauliflower
323	Stewed Prunes (Canned)
24	French Fried Carrots
21	Mashed Rutabagus (Turnips)
94	Fried Parsnips

Instructions for Food Preference Survey

During the course of this experiment you will be asked several times to complete a food preference survey based solely on the foods included in the military rations provided you. There will be a separate preference survey for each of the three categories of rations (Long Range Patrol Food Packet, Meal Combat Individual, Precooked Frozen Meal); however, these instructions are applicable to all such surveys.

We would like you to indicate HOW MUCH YOU LIKE OR DISLIKE each food item and HOW OFTEN YOU WOULD WANT TO EAT the food. After examining the guideline scale at the top of the survey page, please circle the number that best describes your feelings for the particular food item. Notice that a rating of 5 is neutral, meaning that you neither like nor dislike the food. Ratings below 5 indicate dislike, while ratings above 5 indicate like.

Example: If one of the items was –

Danish Pastry 1 2 3 4 5 6 7 8 9

and if you like Danish Pastry a lot, you would respond –

Danish Pastry 1 2 3 4 5 6 7 8 9

whereas if you disliked it slightly, you would respond –

Danish Pastry 1 2 3 4 5 6 7 8 9

After rating HOW MUCH YOU LIKE OR DISLIKE THE FOOD, continue across the same line to the second column labelled "HOW OFTEN you want to eat the food." Decide how many **days per month** you would like to eat the food (0–30). If you want a food 3 meals or more on the same day, it should be counted as **one** day. If you **never** want the food, fill in zero(0). Keep in mind that (a) you should base your estimate of "HOW OFTEN" on the condition that you have only these food items to choose from during the given month and (b) that the number of days per month does **not** have to total 30 across any types or groups of food. That is, the food items should be treated independently.

Example: If you would like bacon for breakfast 15 days per month and sausage 15 days per month, that doesn't mean you can't mark that you'd like ham 10 days per month.

Please remember that you will be given the same survey several times during the course of the experiment and that you are not required to rate items the same each time but rather allow your ratings to vary with your experiences and tastes. Thank you for your cooperation.

Appendix B–4

FOOD PREFERENCE SURVEY: Meal Combat Individual

Name: ____________________ Date: ______________ Circle one: Conn. Minn.

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

Food Item	HOW MUCH you like or dislike the food (1–9)	HOW OFTEN you want to eat the food in days per month (00–30)
Beans with franks	1 2 3 4 5 6 7 8 9	______
Apricots, canned	1 2 3 4 5 6 7 8 9	______
Beans with meatballs	1 2 3 4 5 6 7 8 9	______
Choc. nut roll	1 2 3 4 5 6 7 8 9	______
Fruitcake	1 2 3 4 5 6 7 8 9	______
Beefsteak	1 2 3 4 5 6 7 8 9	______
Pears, canned	1 2 3 4 5 6 7 8 9	______
Chicken or turkey	1 2 3 4 5 6 7 8 9	______
Pecan cake roll	1 2 3 4 5 6 7 8 9	______
Beef slices, potatoes	1 2 3 4 5 6 7 8 9	______
Applesauce	1 2 3 4 5 6 7 8 9	______
Pineapple	1 2 3 4 5 6 7 8 9	______
Ham and eggs	1 2 3 4 5 6 7 8 9	______
Coconut disk	1 2 3 4 5 6 7 8 9	______
Fruit Cocktail	1 2 3 4 5 6 7 8 9	______
Ham, sliced	1 2 3 4 5 6 7 8 9	______
Spaghetti with beef	1 2 3 4 5 6 7 8 9	______
Beef with sauce	1 2 3 4 5 6 7 8 9	______
Peaches, canned	1 2 3 4 5 6 7 8 9	______
Vanilla disk	1 2 3 4 5 6 7 8 9	______
Pork, sliced	1 2 3 4 5 6 7 8 9	______
Sweet choc. disk	1 2 3 4 5 6 7 8 9	______
Tuna fish	1 2 3 4 5 6 7 8 9	______
Crackers	1 2 3 4 5 6 7 8 9	______
Turkey loaf	1 2 3 4 5 6 7 8 9	______

Appendix B–5

FOOD PREFERENCE SURVEY: Precooked Frozen Meal

Name: ______________________ Date: ____________ Circle one: Conn. Minn.

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

Food Item	HOW MUCH you like or dislike the food (1–9)	HOW OFTEN you want to eat the food in days per month (00–30)
Beef Burgandy	1 2 3 4 5 6 7 8 9	______
Noodles	1 2 3 4 5 6 7 8 9	______
String Beans	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______
Beef Sirloin	1 2 3 4 5 6 7 8 9	______
Mashed Potatoes	1 2 3 4 5 6 7 8 9	______
String Beans	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______
Ham	1 2 3 4 5 6 7 8 9	______
Omelet	1 2 3 4 5 6 7 8 9	______
Apple Slices	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______
Omelet	1 2 3 4 5 6 7 8 9	______
Smoky Link Sausage	1 2 3 4 5 6 7 8 9	______
Potato Logs	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______
Salisbury Steak	1 2 3 4 5 6 7 8 9	______
Whipped Potatoes	1 2 3 4 5 6 7 8 9	______
Peas Carrots	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______
Roast Turkey	1 2 3 4 5 6 7 8 9	______
Sweet Potatoes	1 2 3 4 5 6 7 8 9	______
Peas w. Pim entoes	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______
Swiss Steak	1 2 3 4 5 6 7 8 9	______
Whipped Potatoes	1 2 3 4 5 6 7 8 9	______
Peas	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______
French Fried Shrimp	1 2 3 4 5 6 7 8 9	______
Rice	1 2 3 4 5 6 7 8 9	______
Mixed Vegetables	1 2 3 4 5 6 7 8 9	______
Meal Pack	1 2 3 4 5 6 7 8 9	______

Appendix B–6

CANNED FOOD MENU QUESTIONNAIRE

This questionnaire has been designed to find out which menus of canned foods you prefer.

The following pages contain pairs of canned food menus.

– Read each pair of menus.

– Decide which of the pair of menus you prefer.

– For each pair indicate your choice in this booklet by circling either "a" or "b".

Do the same thing for all pairs of menus. Be sure to make a choice for **every** pair and **do not** go back to change any answers. Work as rapidly as you can and do not spend too much time on any item. Circle **only one** answer for each pair of menus. Ask yourself: Which menu of canned foods do I prefer?

– Please begin with Item 1 on the reverse side –

1. a. Beans with meatballs in tomato sauce
   Chocolate nut roll, grape jam, crackers, cocoa
   or
   b. Beefslices and potatoes with gravy
   Fruitcake, grape jam, crackers, cocoa

2. a. Spaghetti with beef chunks in sauce
   Chocolate nut roll, pineapple jam, crackers, cocoa
   or
   b. Ham and eggs, chopped
   Pears, peanut butter, crackers, candy

3. a. Beefsteak with gravy
   Applesauce, cheese spread (cheddar, plain), crackers, candy
   or
   b. Ham, sliced and cooked with juices
   Peaches, cheese spread (cheddar, caraway), crackers, candy

4. a. Beef with spiced sauce
   Apricots, peanut butter, crackers, candy
   or
   b. Beans with meatballs in tomato sauce
   Chocolate nut roll, grape jam, crackers, cocoa

5. a. Beefslices and potatoes with gravy
   Fruitcake, grape jam, crackers, cocoa
   or
   b. Ham and eggs, chopped
   Pears, peanut butter, crackers, candy

6. a. Pork, sliced and cooked with juices
   Fruit cocktail, peanut butter, crackers, candy
   or
   b. Chicken or Turkey, boned
   Peaches, cheese spread (cheddar, pimento), crackers, candy

7. a. Turkey loaf
   Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy
   or
   b. Beef with spiced sauce
   Apricots, peanut butter, crackers, candy

8. a. Beefsteak with gravy
   Applesauce, cheese spread (cheddar, plain), crackers, candy
   or
   b. Beefslices and potatoes with gravy
   Fruitcake, grape jam, crackers, cocoa

9. a. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa
or
b. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy

10. a. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy
or
b. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa

11. a. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy
or
b. Beef with spiced sauce
Apricots, peanut butter, crackers, candy

12. a. Ham and eggs, chopped
Pears, peanut butter, crackers, candy
or
b. Tuna Fish
Peaches, peanut butter, crackers, candy

13. a. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa
or
b. Chicken or Turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy

14. a. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway) crackers, candy
or
b. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa

15. a. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy
or
b. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa

16. a. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy
or
b. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy

17. a. Beef with spiced sauce
Apricots, peanut butter, crackers, candy
or
b. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa

18. a. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy
or
b. Ham and eggs, chopped
Pears, peanut butter, crackers, candy

19. a. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa
or
b. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy

20. a. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa
or
b. Chicken or Turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy

21. a. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa
or
b. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa

22. a. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy
or
b. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway) crackers, candy

23. a. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy
or
b. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy

24. a. Beef with spiced sauce
Apricots, peanut butter, crackers, candy
or
b. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy

25. a. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa
or
b. Tuna Fish
Peaches, peanut butter, crackers, candy

26. a. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa
or
b. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy

27. a. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy
or
b. Ham and eggs, chopped
Pears, peanut butter, crackers, candy

28. a. Beef with spiced sauce
Apricots, peanut butter, crackers, candy
or
b. Chicken or Turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy

29. a. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa
or
b. Tuna Fish
Peaches, peanut butter, crackers, candy

30. a. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy
or
b. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa

31. a. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa
or
b. Tuna Fish
Peaches, peanut butter, crackers, candy

32. a. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy
or
b. Beef with spiced sauce
Apricots, peanut butter, crackers, candy

33. a. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa
or
b. Ham and eggs, chopped
Pears, peanut butter, crackers, candy

34. a. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy
or
b. Tuna Fish
Peaches, peanut butter, crackers, candy

35. a. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa
or
b. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa

36. a. Beef with spiced sauce
Apricots, peanut butter, crackers, candy
or
b. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa

37. a. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy
or
b. Tuna Fish
Peaches, peanut butter, crackers, candy

38. a. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa
or
b. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy

39. a. Ham and eggs, chopped
Pears, peanut butter, crackers, candy
or
b. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy

40. a. Beef with spiced sauce
Apricots, peanut butter, crackers, candy
or
b. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa

41. a. Tuna Fish
Peaches, peanut butter, crackers, candy
or
b. Chicken or Turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy

42. a. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa
or
b. Ham and eggs, chopped
Pears, peanut butter, crackers, candy

43. a. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy
or
b. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa

44. a. Tuna Fish
Peaches, peanut butter, crackers, candy
or
b. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy

45. a. Ham and eggs, chopped
Pears, peanut butter, crackers, candy
or
b. Beef with spiced sauce
Apricots, peanut butter, crackers, candy

46. a. Tuna Fish
Peaches, peanut butter, crackers, candy
or
b. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa

47. a. Chicken or turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy
or
b. Ham and eggs, chopped
Pears, peanut butter, crackers, candy

48. a. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa
or
b. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa

49. a. Chicken or turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy
or
b. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy

50. a. Tuna Fish
Peaches, peanut butter, crackers, candy
or
b. Beef with spiced sauce
Apricots, peanut butter, crackers, candy

51. a. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa
or
b. Chicken or turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy

52. a. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy
or
b. Ham and eggs, chopped
Pears, peanut butter, crackers, candy

53. a. Tuna Fish
Peaches, peanut butter, crackers, candy
or
b. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy

54. a. Spaghetti, with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa
or
b. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa

55. a. Chicken or turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy
or
b. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa

56. a. Pork, sliced and cooked with juices
Fruit cocktail, peanut butter, crackers, candy
or
b. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa

57. a. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy
or
b. Chicken or turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy

58. a. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa
or
b. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa

59. a. Beefslices and potatoes with gravy
Fruitcake, grape jam, crackers, cocoa
or
b. Turkey loaf
Fruitcake cocktail, cheese spread (cheddar, caraway), crackers, candy

60. a. Spaghetti with beef chunks in sauce
Chocolate nut roll, pineapple jam, crackers, cocoa
or
b. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy

61. a. Beans with meatballs in tomato sauce
Chocolate nut roll, grape jam, crackers, cocoa
or
b. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy

62. a. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa
or
b. Beefsteak with gravy
Applesauce, cheese spread (cheddar, plain), crackers, candy

63. a. Chicken or Turkey, boned
Peaches, cheese spread (cheddar, pimento), crackers, candy
or
b. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy

64. a. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy
or
b. Beans with frankfurter chunks in tomato sauce
Applesauce, cheese spread (cheddar, plain), cracker, candy

65. a. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy
or
b. Beans with frankfurter chunks in tomato sauce
Fruitcake, grape jam, crackers, cocoa

66. a. Turkey loaf
Fruit cocktail, cheese spread (cheddar, caraway), crackers, candy
or
b. Ham, sliced and cooked with juices
Peaches, cheese spread (cheddar, caraway), crackers, candy

Appendix B–7

Darwin D. Hendel
University of Minnesota

FROZEN FOOD MENU QUESTIONNAIRE

This questionnaire has been designed to find out which menus of frozen foods you prefer. The following pages contain pairs of frozen food menus.

– Read each pair of menus.

– Decide which of the pair of menus you prefer.

– For each pair indicate your choice in this booklet by circling with "a" or "b".

Do the same thing for all pairs of menus. Be sure to make a choice for every pair and do not go back to change any answers. Work as rapidly as you can and do not spend too much time on any item. Circle only one answer for each pair of menus. Ask yourself: Which menu of frozen foods do I prefer?

–Please begin with item 1 on the reverse side–

1. a. Swiss steak, whipped potatoes, and green peas

or

b. Boneless turkey, white and dark meat, with gravy, glazed sweet potatoes, and peas with pimentos

2. a. Salisbury steak with mushroom sauce, potatoes, and peas and carrots

or

b. Beef sirloin butt steak hashed in creamed potatoes, and green beans

3. a. Egg omelette, apple slices, and ham

or

b. Swiss steak, whipped potatoes, and green peas

4. a. Boneless turkey, white and dark meat, with gravy, glazed sweet potatoes, and peas with pimentos

or

b. Beef cubes with burgundy flavored mushroom sauce, noodles, green beans with onions

5. a. Salisbury steak with mushroom sauce, potatoes, and peas and carrots

or

b. Boneless turkey, white and dark meat, with gravy, glazed sweet potatoes, and peas with pimentos

6. a. Swiss steak, whipped potatoes, and green peas

or

b. Salisbury steak with mushroom sauce, potatoes, and peas and carrots

7. a. Beef sirloin butt steak hashed in cream potatoes, and green beans

or

b. Boneless turkey, white and dark meat, with gravy, glazed, glazed sweet potatoes, and peas with pimentos

8. a. French fried shrimp, yellow rice, and mixed vegetables and breading

or

b. Egg omelette, apple slices, and ham

9. a. Beef cubes with burgundy flavored mushroom sauce, noodles, and green beens with onions

or

b. Egg omelette, potato logs, and sausage

10. a. Beef sirloin butt steak hashed in cream potatoes, and green beans

or

b. Swiss steak, whipped potatoes, and green peas

11. a. Salisbury steak with mushroom sauce, potatoes, and peas and carrots

or

b. French fried shrimp, yellow rice, and mixed vegetables and breading

12. a. Egg omelette, apple slices, and ham

or

b. Boneless turkey, white and dark meat, with gravy, glazed sweet potatoes and peas with pimentos

13. a. Beef sirloin butt steak hashed in cream potatoes, and green beans

or

b. Beef cubes with burgundy flavored mushroom sauce, noodles, and green beans with onions

14. a. Beef sirloin butt steak hashed in cream potatoes, and green beans

or

b. French fried shrimp, yellow rice, and mixed vegetables and breading

15. a. Egg omelette, apple slices, and ham

or

b. Salisbury steak with mushroom sauce, potatoes, and peas and carrots

16. a. Swiss steak, whipped potatoes, and green peas

or

b. Egg omelette, potato logs, and sausage

17. a. French fried shrimp, yellow rice, and mixed vegetables and breading

or

b. Swiss steak, whipped potatoes, and green peas

18. a. Boneless turkey, white and dark meat, with gravy, glazed sweet potatoes, and peas with pimentos

or

b. Egg omelette, potato logs, and sausage

19. a. Beef sirloin butt steak hashed in cream potatoes, and green beans

or

b. Egg omelette, apple slices, and ham

20. a. Swiss steak, whipped potatoes, and green peas

or

b. Beef cubes with burgundy flavored mushroom sauce, noodles, and green beans with onions

21. a. Salisbury steak with mushroom sauce, potatoes, and peas and carrots

or

b. Egg omelette, potato logs, and sausage

22. a. Boneless turkey, white and dark meat, with gravy, glazed sweet potatoes, and peas with pimentos

or

b. French fried shrimp, yellow rice and mixed vegetables and breading

23. a. Beef cubes with burgundy flavored mushroom sauce, noodles, and green beans with onions

or

b. French fried shrimp, yellow rice, and mixed vegetables and breading

24. a. Egg omelette, potato logs, and sausage

or

b. French fried shrimp, yellow rice, and mixed vegetables and breading

25. a. Beef cubes with burgundy flavored mushroom sauce, noodles, and green beans with onions

or

b. Egg omelette, apple slices, and ham

26. a. Egg omelette, potato logs, and sausage

or

b. Egg omelette, apple slices, and ham

27. a. Salisbury steak with mushroom sauce

or

b. Beef cubes with burgundy flavored mushroom sauce, noodles, green beans with onions

28. a. Egg omelette, potato logs, and sausage

or

b. Beef sirloin butt steak, mashed in cream potatoes, and green beans

Appendix C. Food Consumption Forms and Nutritive Values

1. Instructions for completing daily food log.
2. Daily canned (MCI) food log.
3. Daily frozen ration food log.
4. Nutritive values for canned (MCI) rations.
5. Nutritive values and method of computation for frozen rations.

Appendix C–1

INSTRUCTIONS FOR DAILY FOOD LOG

Each day participants should turn in their daily log of food items eaten with the weights of the portions not entirely consumed and their ratings of how well they liked or disliked each item. This can be done by filling in the appropriate columns on the food list. Also, entries should be made (on the back of the sheet if necessary) for any foods, beverages, and snacks consumed whether or not they were provided by the people running the experiment. The purpose of this record is to provide the experimenters with a complete listing of your daily food and beverage consumption. For accuracy's sake, please fill in the data immediately after finishing each meal or snack.

In the first column labelled "Amount Left" please note the amount (to the nearest gram) remaining of any food item selected for eating but not completely consumed. Please use the dietary scales provided to determine this weight. In the adjacent column, labelled "Time", write the time at which the item was eaten using 30 minute intervals from 0000 to 2400 hours. If an item was completely eaten, then mark "0" in the "Amount Left" column.

Any item that was tasted or selected for eating should be given a rating on a nine-point scale, nine meaning "like extremely" and one meaning "dislike extremely" with the intermediate points indicating intermediate degrees of liking and disliking.

The next column indicates whether the food was eaten alone or in the company of one or more people. Where the food was eaten is to be shown as Home (H), at Work (W), or Other place (O). Also record in the "Pace" column whether you ate a very liesurely meal (1), a moderately paced meal (2), or a very hurried meal (3).

In the last column, labelled "Hunger", you are to rate the degree of hunger you were experiencing before beginning your meal or snack. The same number should be used for each item eaten in a given mealtime (snack-time). Use the following guide to determine the degree of hunger:

Degree	Description of Hunger
1	Hot Hungry
2	Slightly Hungry
3	Moderately Hungry
4	Very Hungry
5	Extremely Hungry

All beverages except water should be listed for each day in the lower portion of the log. Write in the name of the beverage, the time of each drinking occasion (0000–2400), the number of cups (approximately 8 oz) drunk on each drinking occasion, and the number teaspoons of sugar (if any) used per cup.

Finally, we would like you to log in bread and toast consumption in number of slices and the hours these were consumed.

Many Thanks. We appreciate your cooperation. If any questions, please call me COLLECT at 617–653–1000 Ext. 2148/2449. BON APPETIT!

Curt Graeber – Natick Laboratories

NOTE: If you happen to eat the same food item two or more times on the same day, please use additional food log forms to record the data for each additional time you ate that food.

Appendix C–2

DAILY FOOD LOG – MEAL COMBAT INDIVIDUAL / Wgt._____lbs. Subj I.D._____Date_____

Food Item	Amount Left(g)	Time	Rating (1–9)	Alone? Yes/No	Where? H/W/O	Pace 1–3	Hunger 1–5
M01 Beans/franks							
MO2 Beans/meatballs							
M03 Beef w sauce							
M04 Beefsteak							
M05 Beefslices/pot.							
M06 Chicken/turkey							
M07 Ham & eggs							
M08 Ham, sliced							
M09 Spaghetti							
M10 Pork, sliced							
M11 Tuna fish							
M12 Turkey loaf							
Canned fruit:							
M13 Apricots							
M14 Pears							
M15 Peaches							
M16 Fruit cocktail							
M17 Applesauce							
Desserts:							
M18 Choc nut roll							
M19 Fruitcake							
M20 Sweet choc disk							
M21 Coconut disk							
M22 Coc fudge disk							
M23 Vanilla disk							
M24 Crackers							
M25 Cheese, plain							
M26 Cheese, caraway							
M27 Cheese, pimiento							
M28 Jam, pineapple							
M29 Jam, grape							
M30 Jam, peach							
M31 Jam, apricot							
M32 Peanut butter							

Bread(toast) —— Time/No. slices:	/	/	/	/
Beverage:__________Time/No. cups:	/	/	/	/
Beverage:__________Time/No. cups:	/	/	/	/
Beverage:__________Time/No. cups:	/	/	/	/
Beverage:__________Time/No. cups:	/	/	/	/

Comments:

Appendix C–3

DAILY FOOD LOG – PRE–FROZEN MEAL / Wgt.____lbs. Subj I.D.____Date____

Food Item	Amount Left(g)	Time	Rating (1–9)	Alone? Yes/No	Where? H/W/O	Pace 1–3	Hunger 1–5
F11 Beef burgundy							
F12 Noodles							
F13 String beans							
Overall rating of meal pack							
F21 Beef sirloin							
F22 Creamed potatoes							
F23 String Beans							
Overall rating of meal pack							
F31 Ham							
F32 Omelet							
F33 Apple slices							
Overall rating of meal pack							
F41 Omelet							
F42 Sausages							
F43 Potato logs							
Overall rating of meal pack							
F51 Salisbury steak							
F52 Whipped potatoes							
F53 Peas & carrots							
Overall rating of meal pack							
F61 Roast turkey							
F62 Sweet potatoes							
F63 Peas w pimento							
Overall rating of meal pack							
F71 Swiss steak							
F72 Whipped potatoes							
F73 Peas							
Overall rating of meal pack							
F81 Shrimp, fr. fried							
F82 Yellow rice							
F83 Mixed veget.							
Overall rating of meal pack							

Bread(toast) –– Time/No. slices:	/	/	/	/
Beverage:________Time/No. cups:	/	/	/	/
Beverage:________Time/No. cups:	/	/	/	/
Beverage:________Time/No. cups:	/	/	/	/
Beverage:________Time/No, cups:	/	/	/	/

Comments:

Appendix C-4

TABLE C-1
RECORD OF NUTRITIVE VALUES

Meal, Combat, Individual

Food Item	Weight oz.	Weight gm.	Energy Cal.	Protein gm.	Fat gm.	Carbohydrate gm.
	Values per Serving					
Meat components						
Beans w. franks	11.75	333.11	396	19.7	19.7	36.0
Beans w. meatballs	12.00	340.20	517	35.7	25.9	43.2
Beef w. sauce	5.75	163.01	303	32.4	17.9	0.7
Beefsteak	5.50	155.92	304	34.0	17.5	0.3
Beef slices & potatoes	11.50	326.02	414	33.3	25.4	11.1
Chicken or turkey, boned	5.75	163.01	341	31.9	22.7	0.2
Ham & eggs, chopped	5.50	155.92	335	20.7	26.7	1.6
Ham, sliced cooked w. juices	5.50	155.92	312	30.1	20.0	0.9
Spaghetti w. beef chunks	12.00	340.20	520	26.2	31.0	34.0
Pork, sliced cooked w. juices	5.50	155.92	320	33.5	19.3	0.5
Tuna fish	3.50	99.23	286	24.0	20.3	0.0
Turkey loaf	5.75	163.01	344	31.3	19.9	7.7
Canned fruit						
Apricots	8.75	248.06	213	1.5	0.2	54.6
Pears	8.50	240.98	182	0.4	0.4	47.2
Peaches	8.75	248.06	194	1.0	0.2	49.9
Fruit Cocktail	8.75	248.06	188	1.0	0.2	48.9
Apple sauce	8.50	240.97	219	0.5	0.2	57.4
Pineapple	8.50	240.97	178	0.7	0.2	46.7

TABLE C–1 (cont'd)
RECORD OF NUTRITIVE VALUES

Meal, Combat, Individual

Food Item	Values per Serving					
	Weight oz.	Weight gm.	Energy Cal.	Protein gm.	Fat gm.	Carbohydrate gm.
<u>Desserts</u>						
Choc. nut roll	3.50	99.23	339	6.2	14.0	51.6
Fruitcake	5.00	141.75	539	6.8	23.5	80.4
Pecan cake roll	4.00	113.40	448	8.6	21.7	56.7
Sweet Choc. disk	2.00	56.70	289	7.1	18.0	29.7
Coconut disk	1.50	42.52	185	1.3	7.4	31.0
Choc. fudge disk	1.75	49.61	203	2.0	8.2	36.1
Vanilla disk	1.75	49.61	216	2.1	7.9	36.2
Crackers	1.02	28.92	128	2.9	3.8	20.3

Taken from: NL Record of Nutritive Values, February 1972
Food Laboratory - based on average values
obtained from laboratory analysis (M. Klicka)

Nutritional Analysis for Precooked Frozen Meals*

Individual nutrient values for each component were not directly available from laboratory analyses, instead they were calculated by applying proportional weighting factors (derived from USDA Handbook No. 8) to total nutritive values obtained from laboratory analyses of the whole meal (see Table C–5a).

Method of Computation:

A, B, and C - components of meal

W = weight of meal = $W_A + W_B + W_C$

V = total nutrient value of meal

V_A, V_B, V_C = nutrient values per gram of component

$V = W_A V_A + W_B V_B + W_C V_C$

Weighting Factors Derived from USDA Handbook No. 8 (Consumer and Food Economics Research Division, Agriculture Research Service):

$$V_A/V_B = \lambda_{AB} \quad V_B/V_C = \lambda_{BC} \quad V_A/V_C = \lambda_{AC}$$

Values chosen for V_A, V_B and V_C correspond to those listed for that component in Handbook No. 8 (see item numbers on Table C–5b).

$$V = W_A V_A + W_B V_B + W_C V_C \qquad V_A = V_B \lambda_{AB}, \quad V_C = V_B/\lambda_{BC}$$

$$V = W_A V_B \lambda_{AB} + W_B V_B + W_C V_B/\lambda_{BC}$$

$$V = V_B \, (W_A \lambda_{AB} + W_B + W_C/\lambda_{BC})$$

$$V_B = V/(W_A \lambda_{AB} + W_B + W_C/\lambda_{BC})$$

$$V_A = V_B \lambda_{AB}$$

$$V_C = V_B/\lambda_{BC}$$

TABLE ENTRIES: Nutritive values per serving = $V_A W_A$ or $V_B W_B$ or $V_C W_C$

*We wish to thank the following individuals at NARADCOM for assistance in determining nutritive values: Miss Virginia M. White, R.D., Experimental Kitchens, Food Engineering Laboratory; Mrs. Miriam H. Thomas, Nutritionist, Food Sciences Laboratory; Dr. Edward W. Ross, Jr. Staff Mathematician, Technical Directors Office.

TABLE C-2a

RECORD OF NUTRITIVE VALUES:

Meals, Pre-cooked Frozen

	USDA Item No.	Weight gm.	Energy Cal.	Protein gm.	Fat gm.	Carbohydrate gm
			Values per Serving			
Meal 1						
Beef Burgundy	255	143	320.3	41.3	17.9	0.0
Nocdles	1378	74	118.4	2.8	2.9	18.9
String Beans	192	56	17.9	0.8	0.2	3.5
Meal 2						
Beef Sirloin	363	117	315.9	29.0	19.6	0.0
Mashed Potatoes	1808	90	72.0	1.6	1.8	15.2
String Beans	192	53	10.6	0.8	0.0	3.2
Meal 3						
Ham	1706	35	69.7	11.0	3.0	0.0
Omelet	975	87	144.3	10.1	13.1	1.8
Apple Slices	29	56	48.9	0.1	6.4	11.6
Meal 4						
Omelet	975	97	208.4	12.1	14.6	2.7
Smoky Link Sausage	2014	34	182.6	7.1	17.6	21.9
Potatoe Log	1791	63	161.1	2.3	8.6	0.0
Meal 5						
Salisbury Steak	370	162	429.0	30.5	28.2	0.0
Whipped Potatoes	1808	78	67.2	1.1	1.9	20.0
Peas & Carrots	1535	57	28.0	1.4	0.2	9.4
Meal 6						
Roast Turkey	2335	117	196.6	41.4	5.8	0.0
Sweet Potatoes	2251	103	165.1	1.4	4.1	25.8
Peas w. Pimentoe	1530	70	45.4	3.8	0.0	6.3
Meal 7						
Swiss Steak	246	128	294.4	43.5	12.8	0.0
Whipped Potatoes	1808	68	74.8	1.4	2.7	13.5
Peas	1530	60	47.4	3.0	1.2	9.0
Meal 8						
French Fried Shrimp	2043	81	275.4	15.4	17.8	12.2
Rice	1874	63	100.8	1.3	0.1	21.4
Mixed Vegetables	2404	64	60.2	1.9	0.4	12.8

TABLE C–2b

RECORD OF NUTRITIVE VALUES Flight Meals, Cooked, Frozen IP/PD S-13-1 Date 9 May 1975 MB

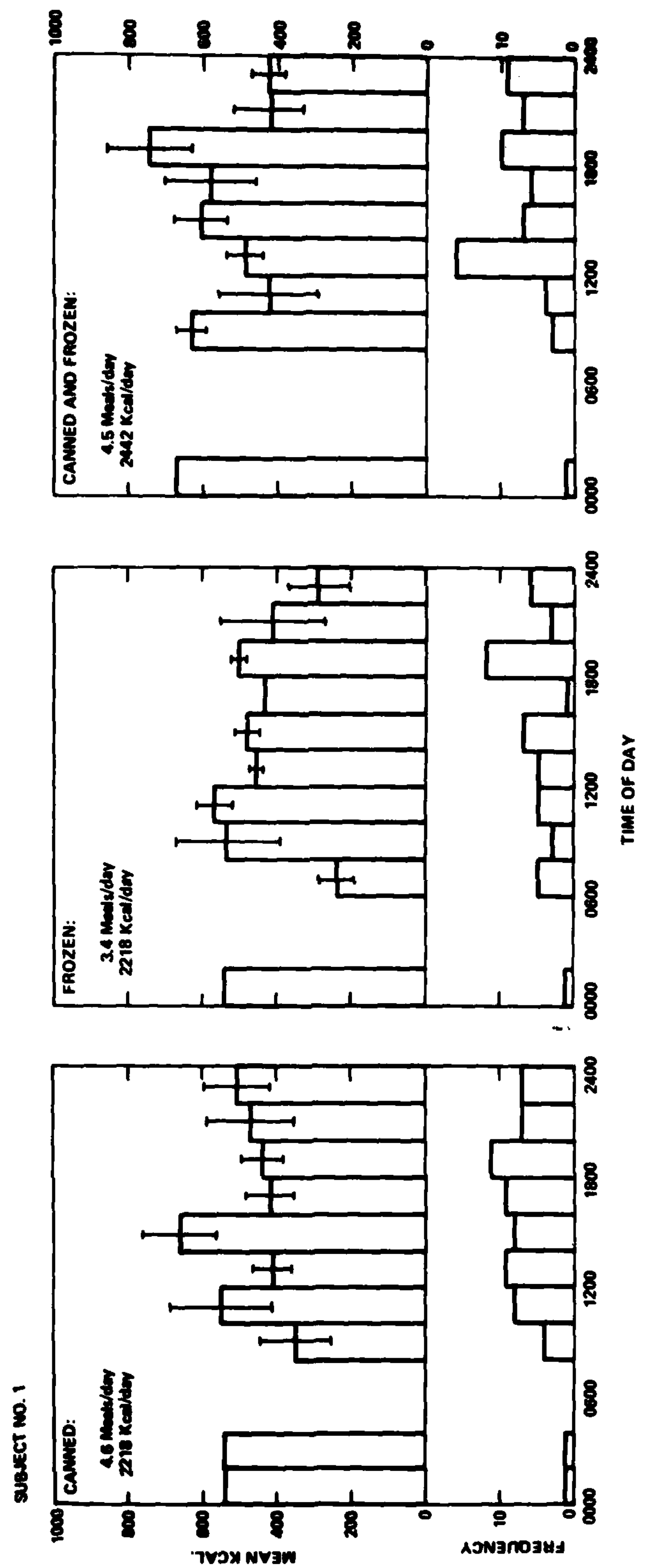
Ration Item	Weight oz.	Weight gm.	Water gm.	Energy cal.	Protein gm.	Fat gm.	Carbohydrate gm.	Calcium mg.	Iron mg.	Vitamins A I.U.	C mg.	Thiamine mg.	Riboflavin mg.	Niacin mg.
Beef burgundy, noodles, string beans	11.46	325.00	232.4	(458)	44.8	21.1	22.4	52	4.9	--	tr	0.10	0.39	4.5
Beef sirloin, cr. potatoes, string beans	10.12	287.00	210.9	(402)	32.1	22.1	18.4	66	5.2	--	tr	0.06	0.37	6.3
Ham omelet, apple slices	7.94	225.00	172.3	(263)	21.1	13.7	13.7	72	2.9	tr	tr	0.20	0.38	2.0
Omelet, sm. link sausage, potato logs	8.25	234.00	143.2	(552)	21.5	40.9	24.6	80	3.5	tr	tr	0.14	0.42	2.6
Salisbury steak, wh. potato, peas & carrots	11.92	338.00	237.9	(524)	33.5	30.4	29.4	91	4.7	4000	17	0.10	0.30	5.4
Roast turkey, sw. potatoes, peas s/pimentos	12.38	351.00	257.3	(407)	48.1	10.2	31.2	67	5.3	6550	24		0.39	12.3
Swiss steak, whipped potatoes peas	11.85	336.00	246.3	(420)	47.4	15.8	22.5	64	5.7	640	18		0.30	7.7
Fr. fried shrimp, rice, mixed vegetables	8.89	252.00	163.8	(431)	20.4	18.6	45.4	111	3.3	3230	11	0.18	0.13	2.5

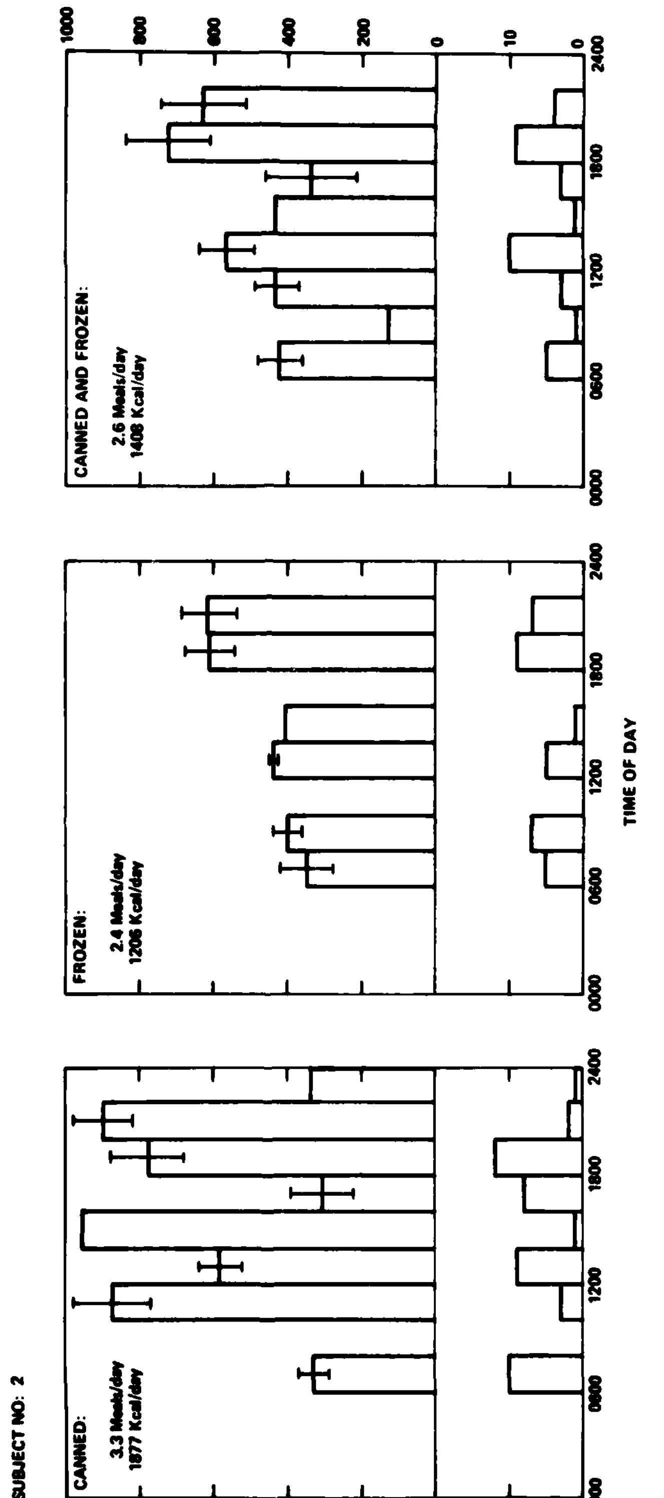
NOTE: The meals analyzed for nutrient content were procured for test and evaluation under Contract DBAK 03-74-C-0233 at New Britain General Hospital, New Britain, Connecticut and the University of Minnesota, Minneapolis, Minnesota. The Beef Burgundy, Beef Sirloin, Salisbury Steak and French Fried Shrimp menus were produced during November 1974 (rec'd 20 Nov). The remaining menus were produced during August 1974 (rec'd 30 Aug). The data reflect analysis of three 3-meal composites of each menu.

AMXRE Form 709 (3 parts)
3 August 1964

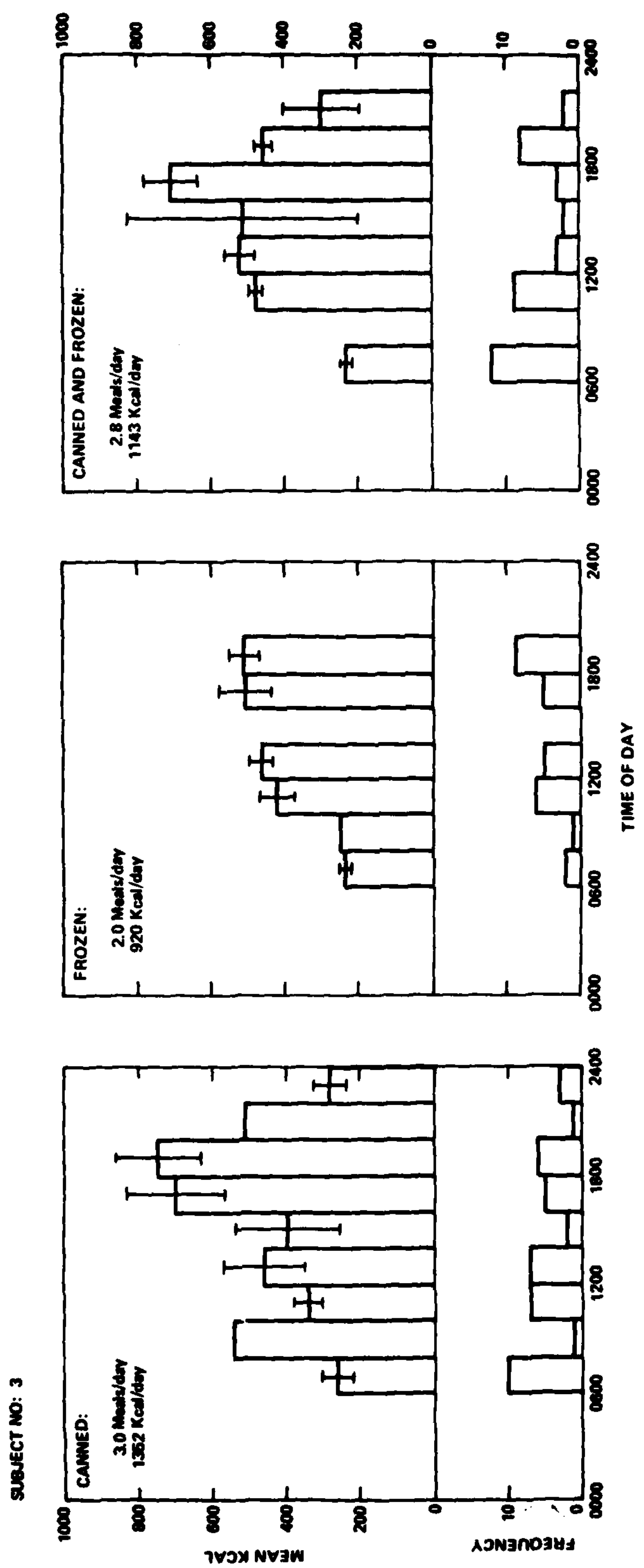
Appendix D. Individual Food Consumption Patterns: Variations in frequency and mean sizes of meals as a function of time of day for subjects during the *ad libitum* stages. Vertical bars indicate standard errors of the mean for meal sizes.

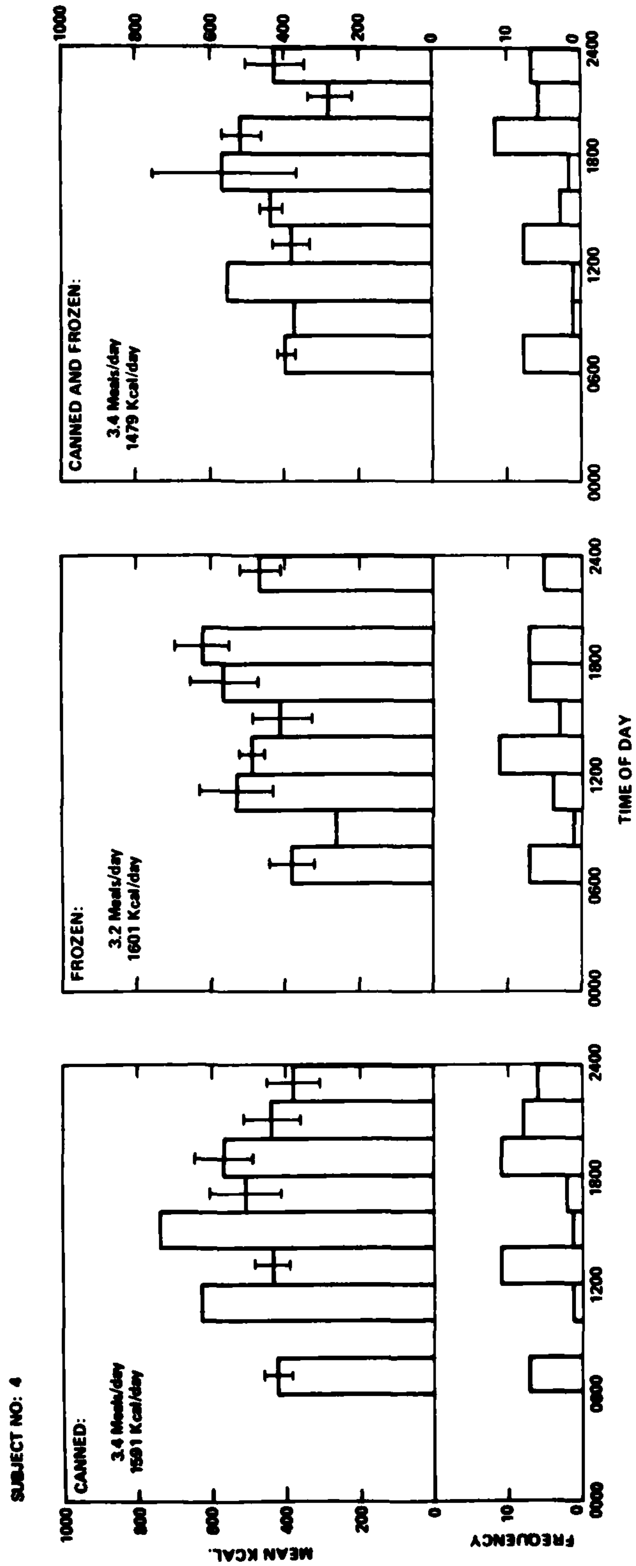
1	Subject No. 1
2	Subject No. 2
3	Subject No. 3
4	Subject No. 4
5	Subject No. 31
6	Subject No. 53
7	Subject No. 55
8	Subject No. 56
9	Subject No. 57
10	Subject No. 61
11	Subject No. 62
12	Subject No. 64

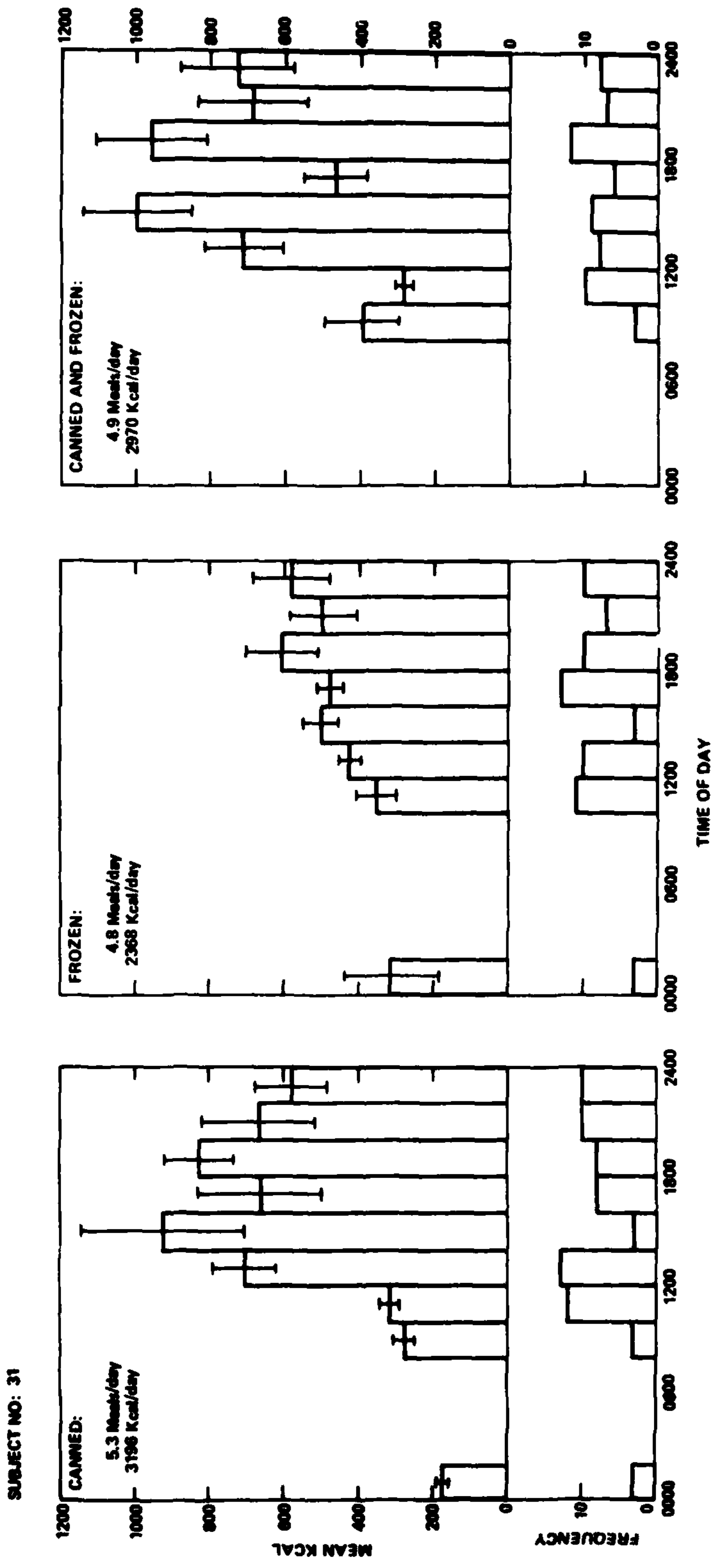

SUBJECT NO. 1
CANNED:
4.6 Meals/day
2218 Kcal/day
FROZEN:
3.4 Meals/day
2218 Kcal/day
CANNED AND FROZEN:
4.5 Meals/day
2442 Kcal/day
MEAN KCAL.
FREQUENCY
TIME OF DAY
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400



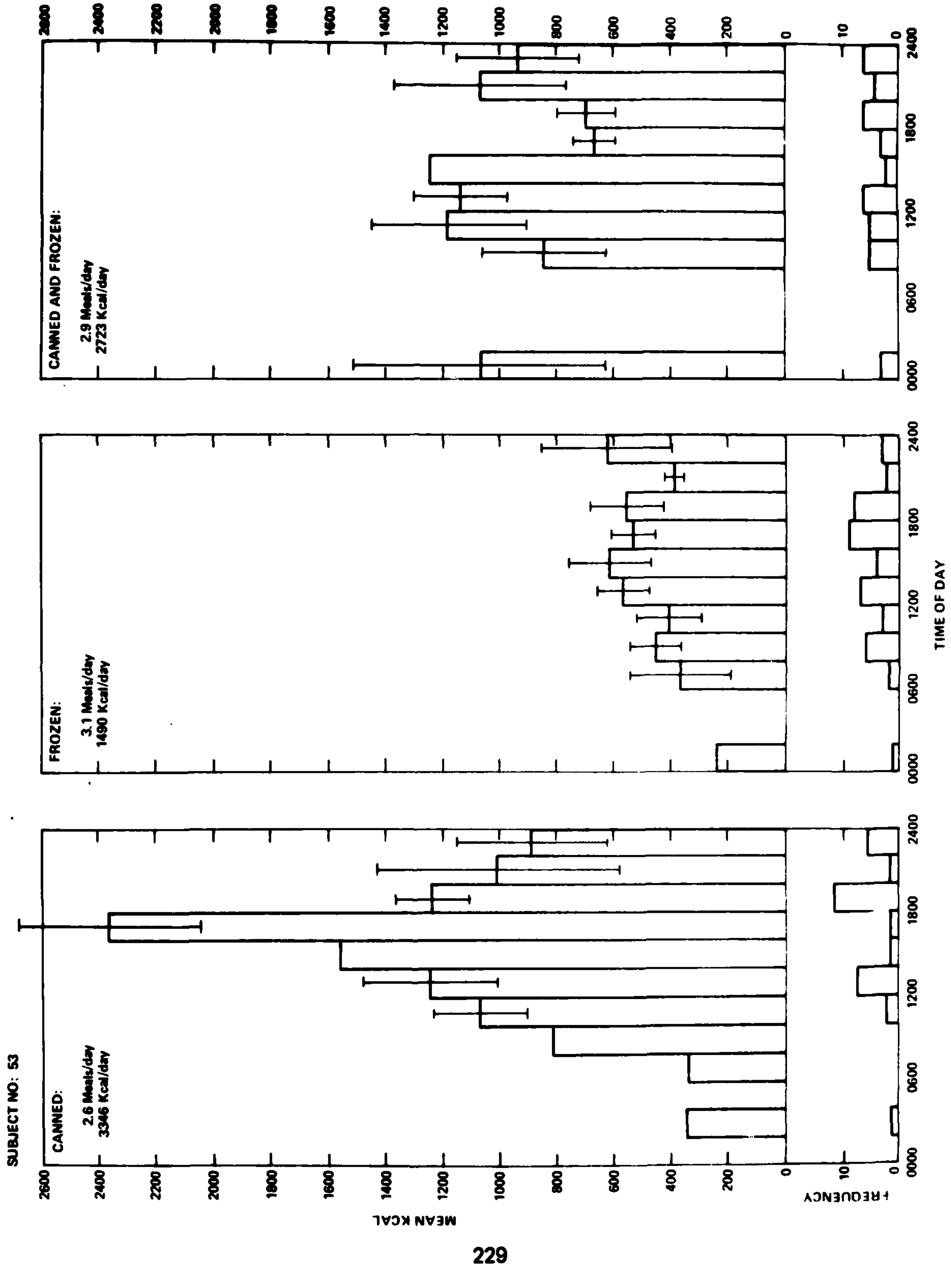
SUBJECT NO: 2
CANNED:
3.3 Meals/day
1877 Kcal/day
FROZEN:
2.4 Meals/day
1206 Kcal/day
CANNED AND FROZEN:
2.6 Meals/day
1408 Kcal/day
MEAN KCAL.
FREQUENCY
TIME OF DAY
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400

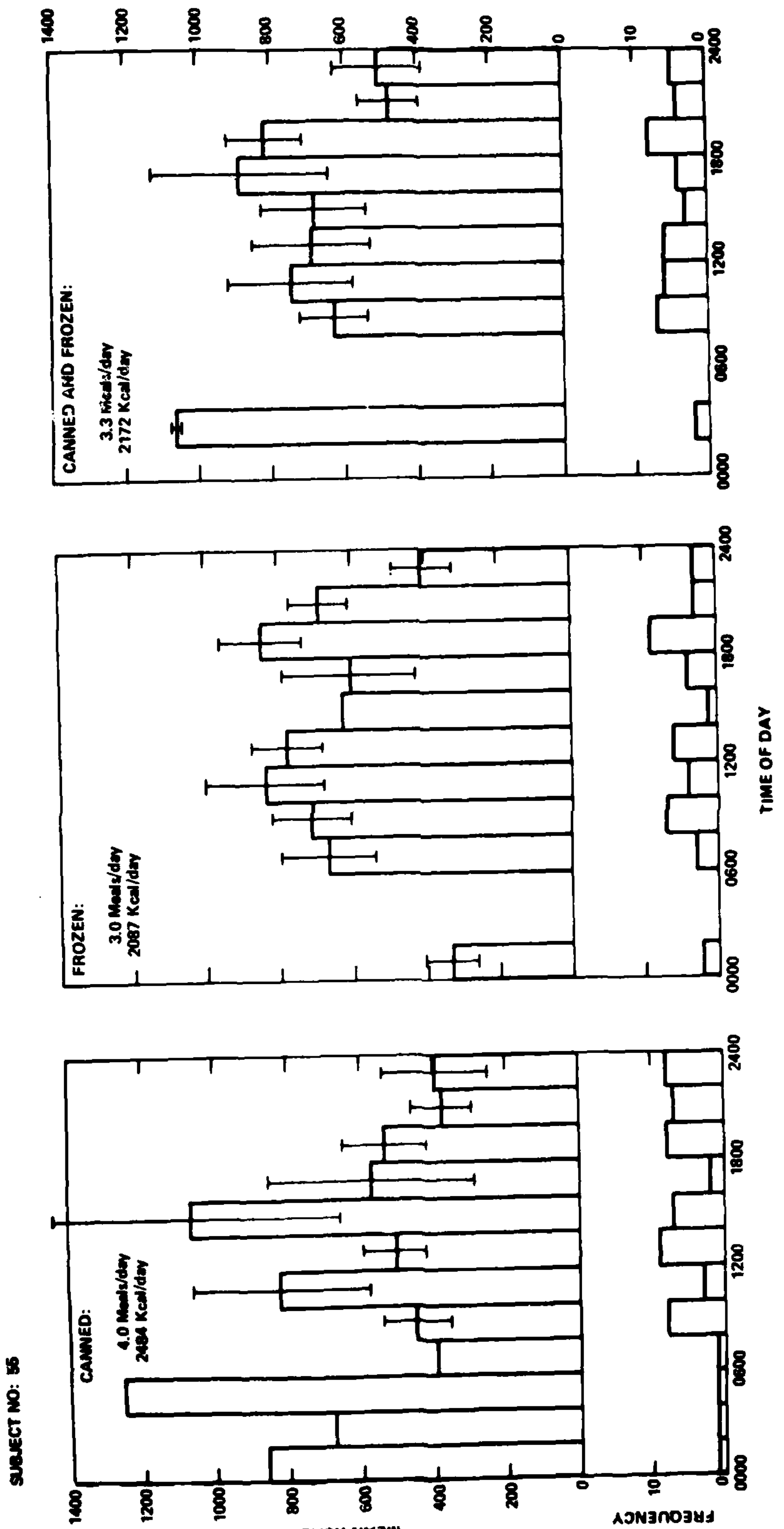

SUBJECT NO: 3
CANNED:
3.0 Meals/day
1352 Kcal/day
FROZEN:
2.0 Meals/day
920 Kcal/day
CANNED AND FROZEN:
2.8 Meals/day
1143 Kcal/day
MEAN KCAL
1000
800
600
400
200
0
FREQUENCY
10
0
0000
0600
1200
1800
2400
TIME OF DAY

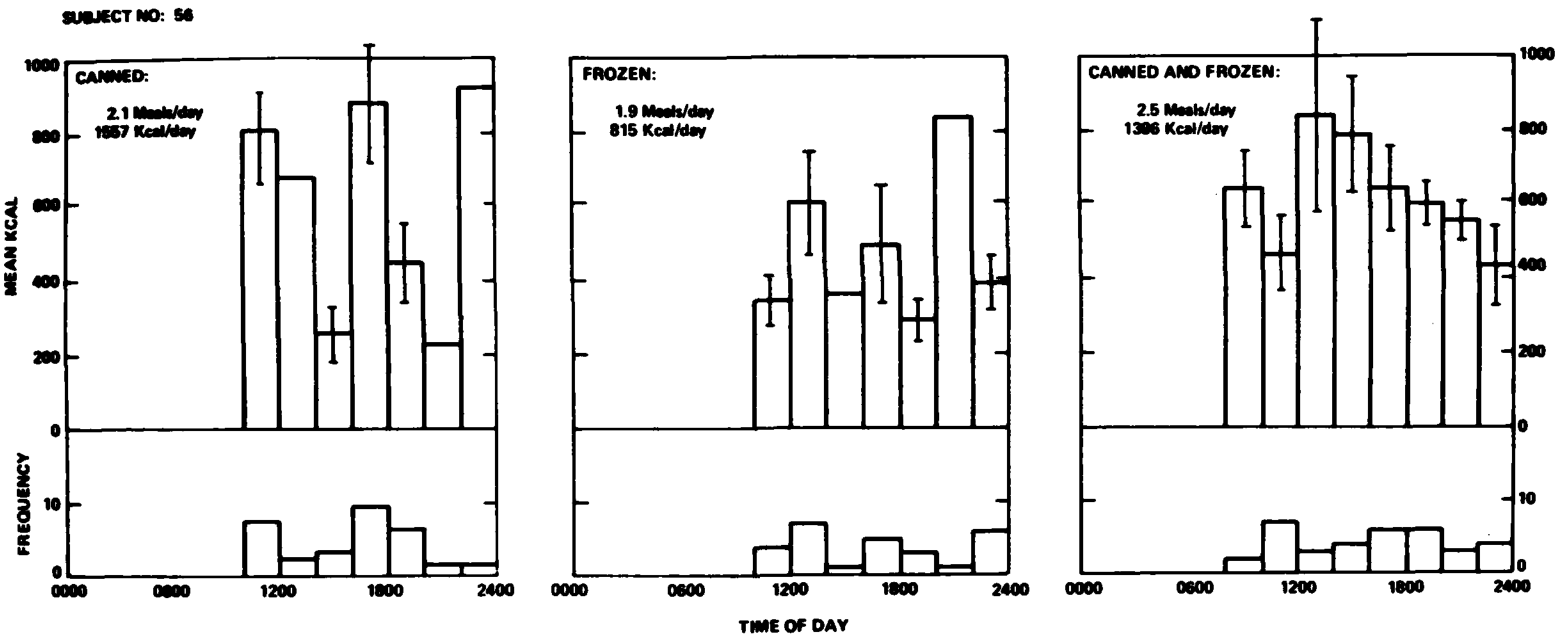

SUBJECT NO: 4
CANNED:
3.4 Meals/day
1591 Kcal/day
FROZEN:
3.2 Meals/day
1601 Kcal/day
CANNED AND FROZEN:
3.4 Meals/day
1479 Kcal/day
MEAN KCAL.
FREQUENCY
TIME OF DAY
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400



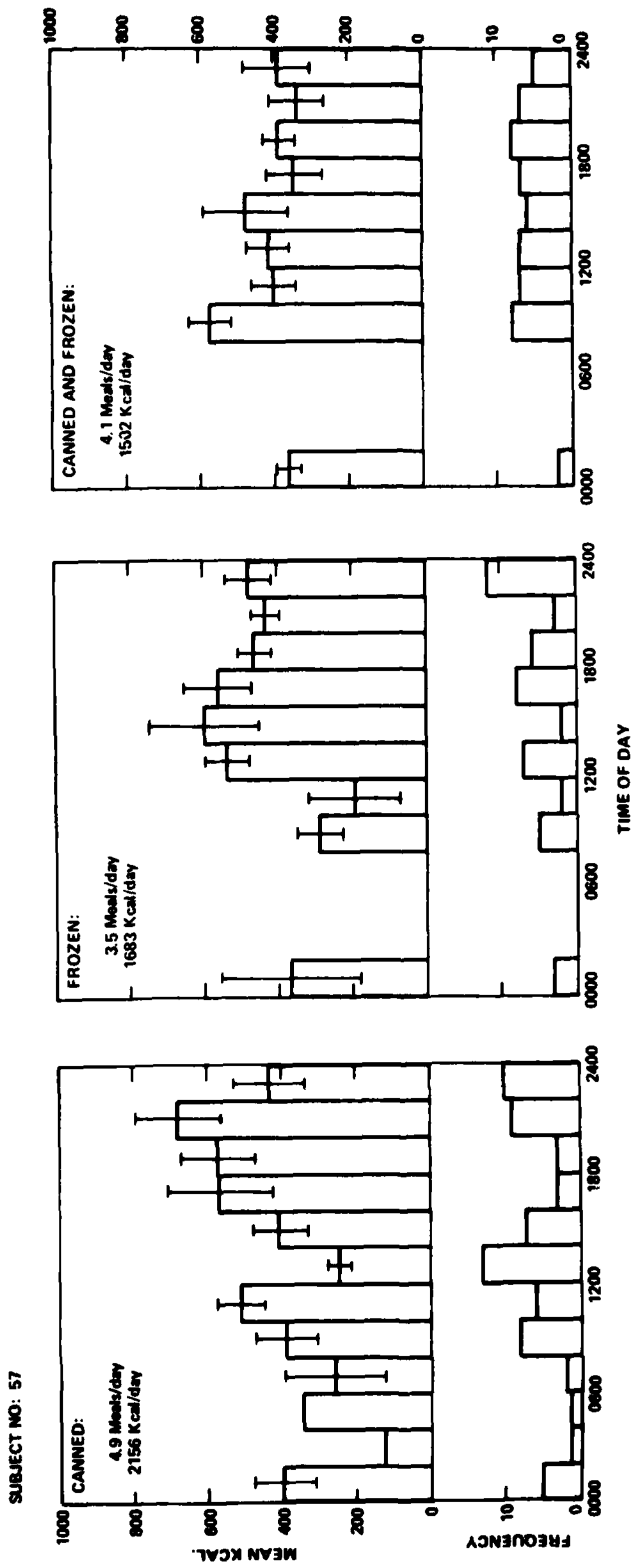
SUBJECT NO: 31
CANNED:
5.3 Meals/day
3198 Kcal/day
FROZEN:
4.8 Meals/day
2368 Kcal/day
CANNED AND FROZEN:
4.9 Meals/day
2970 Kcal/day
MEAN KCAL
FREQUENCY
TIME OF DAY
1200
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400


SUBJECT NO: 53
CANNED:
2.6 Meals/day
3346 Kcal/day
FROZEN:
3.1 Meals/day
1490 Kcal/day
CANNED AND FROZEN:
2.9 Meals/day
2723 Kcal/day
MEAN KCAL
FREQUENCY
TIME OF DAY

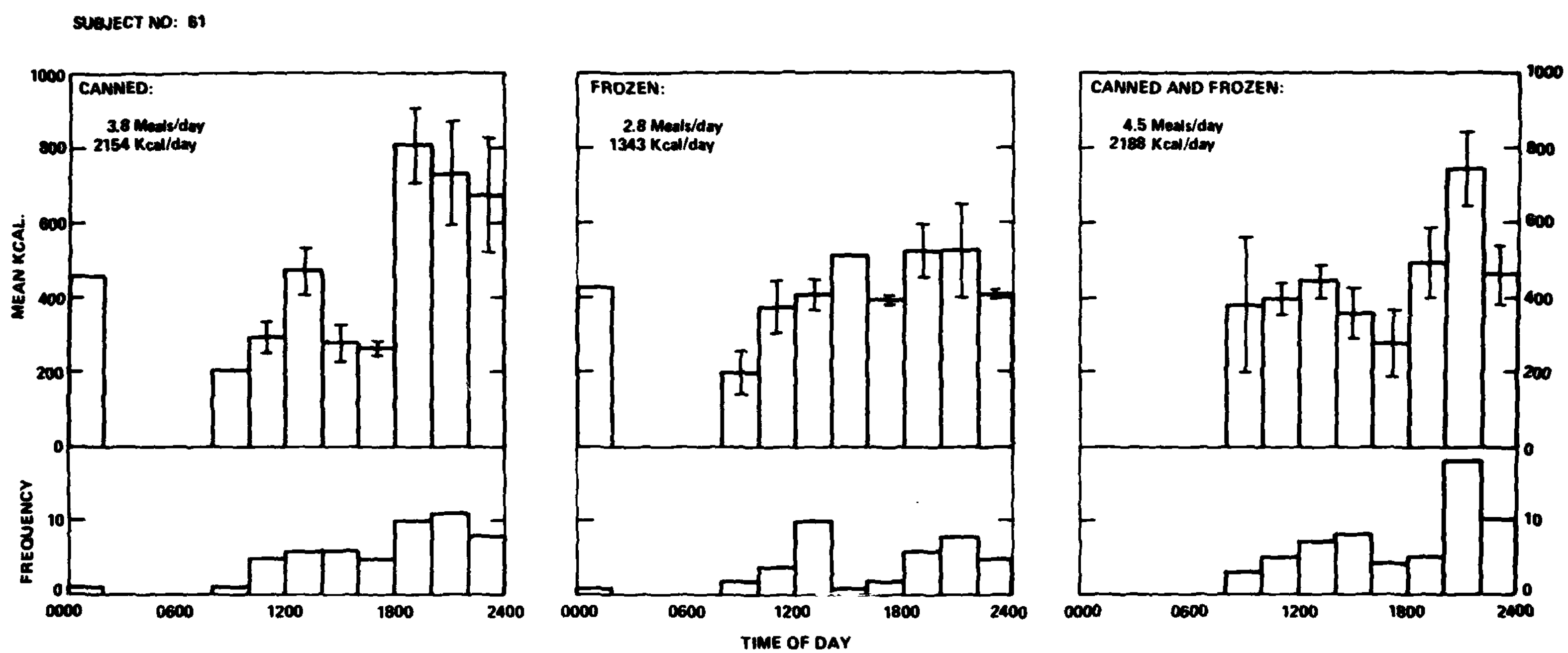

SUBJECT NO: 55
CANNED:
4.0 Meals/day
2484 Kcal/day
FROZEN:
3.0 Meals/day
2087 Kcal/day
CANNED AND FROZEN:
3.3 Meals/day
2172 Kcal/day
MEAN KCAL.
FREQUENCY
TIME OF DAY
1400
1200
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400

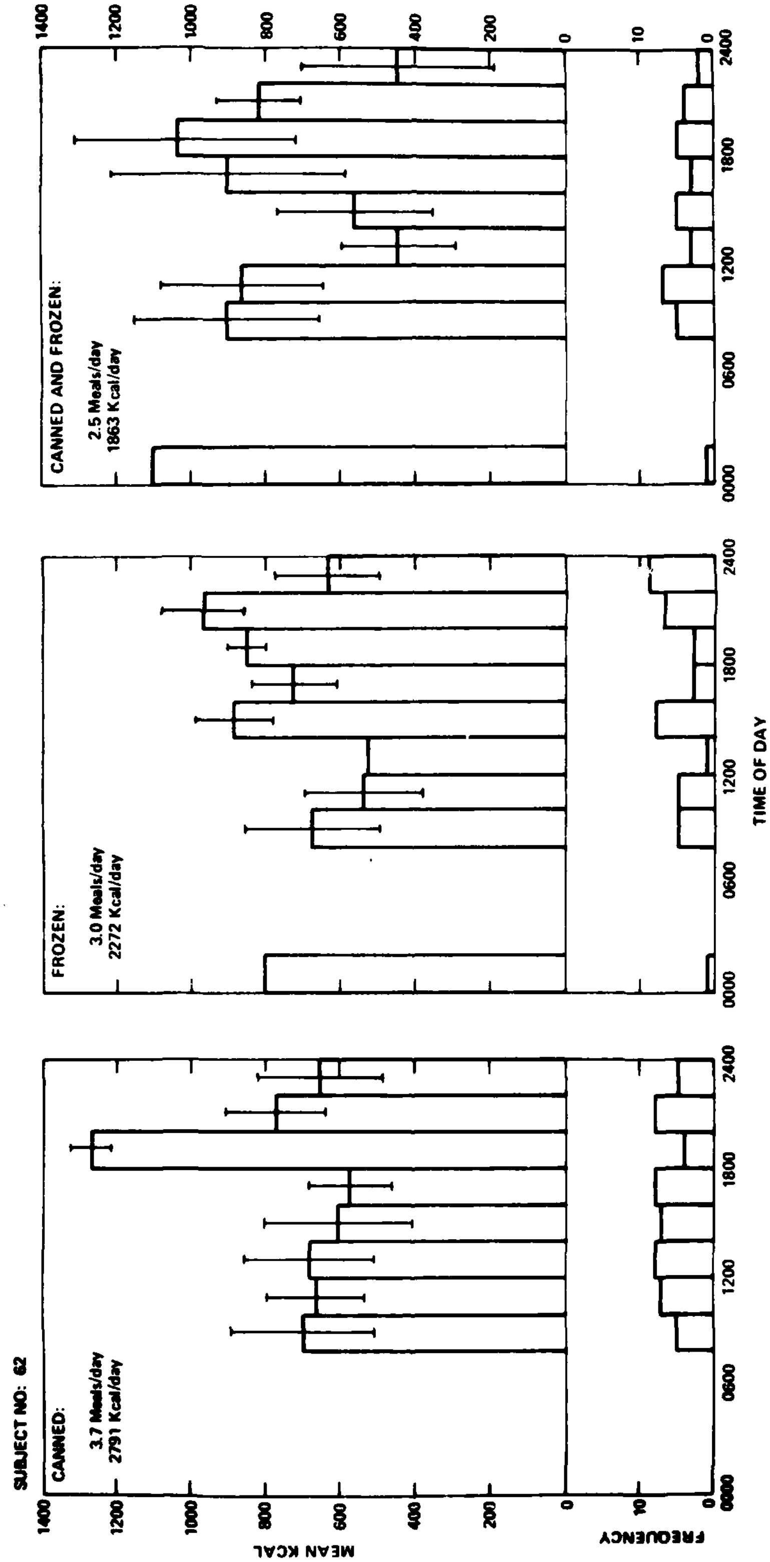


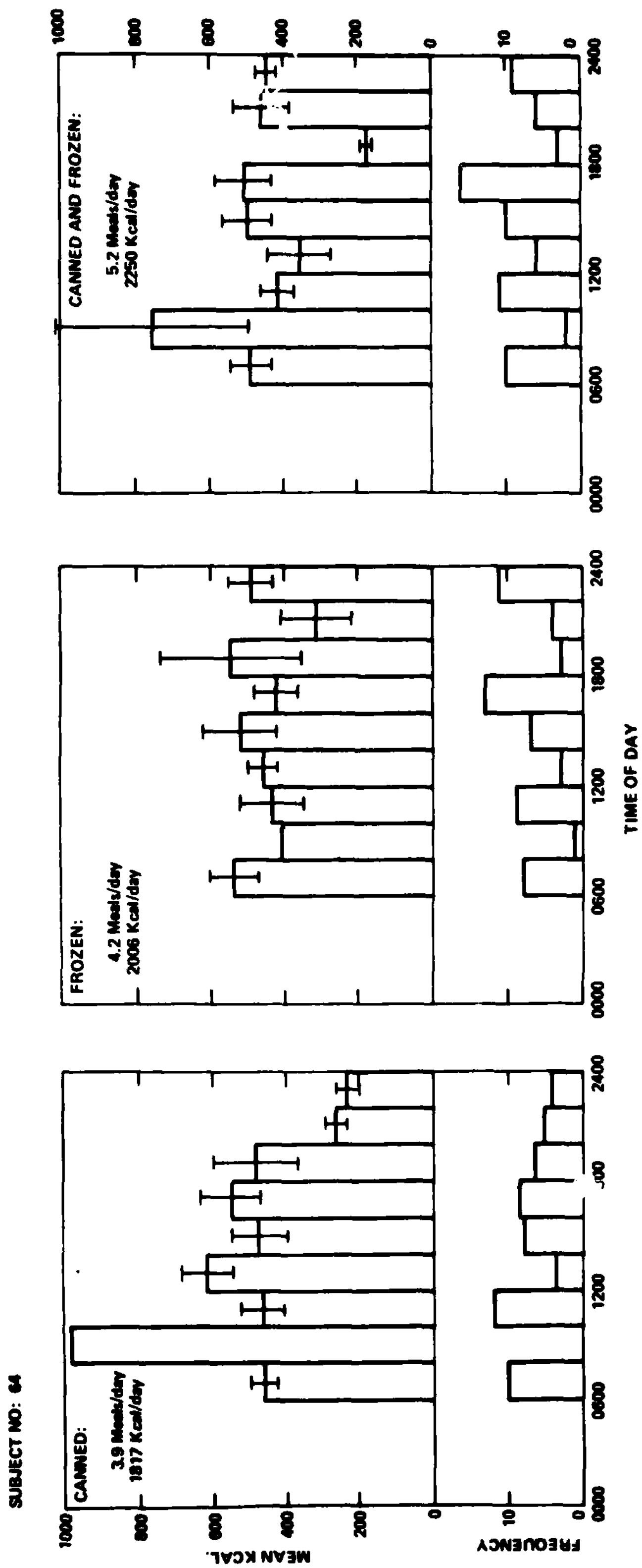
SUBJECT NO: 56
CANNED:
2.1 Meals/day
1557 Kcal/day
FROZEN:
1.9 Meals/day
815 Kcal/day
CANNED AND FROZEN:
2.5 Meals/day
1386 Kcal/day
MEAN KCAL
FREQUENCY
TIME OF DAY



SUBJECT NO: 57
CANNED:
4.9 Meals/day
2156 Kcal/day
FROZEN:
3.5 Meals/day
1683 Kcal/day
CANNED AND FROZEN:
4.1 Meals/day
1532 Kcal/day
MEAN KCAL.
FREQUENCY
TIME OF DAY
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400


SUBJECT NO: 61
CANNED:
3.8 Meals/day
2154 Kcal/day
FROZEN:
2.8 Meals/day
1343 Kcal/day
CANNED AND FROZEN:
4.5 Meals/day
2188 Kcal/day
MEAN KCAL.
FREQUENCY
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400
TIME OF DAY


SUBJECT NO: 62
CANNED:
3.7 Meals/day
2791 Kcal/day
FROZEN:
3.0 Meals/day
2272 Kcal/day
CANNED AND FROZEN:
2.5 Meals/day
1863 Kcal/day
MEAN KCAL
FREQUENCY
TIME OF DAY
1400
1200
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400


SUBJECT NO: 64
CANNED:
3.9 Meals/day
1817 Kcal/day
FROZEN:
4.2 Meals/day
2006 Kcal/day
CANNED AND FROZEN:
5.2 Meals/day
2250 Kcal/day
MEAN KCAL.
FREQUENCY
TIME OF DAY
1000
800
600
400
200
0
10
0
0000
0600
1200
1800
2400

Appendix E. Self-measurement Forms

1. Instructions for performing measurements.
2. Self-measurement recording sheet.
3. Random number addition task forms.
4. Tapping task instructions and form.
5. Circadian rhythm questionnaire.

Appendix E–1

Instructions for Self-measurement

The first line of each self-measurement recording sheet will have space for identifying the entire sheet (Exp. No., Subject I.D. No., etc.). To avoid mix-up, the sheets should be numbered consecutively, in the upper right hand corner.

The second line of the data sheet consists of column headings of the biological variables which will be measured. Above the first two columns at the left of each sheet write the year, e.g., 1974. Throughout the entire study record all measurement times with reference to one time zone (your home standard time zone such as Central Standard Time).

Record time to nearest minute, based on 24-hour clock with midnight=00^{00}; e.g., 1:20 A.M. should be recorded as 01^{20}, 1:20 P.M. should be recorded as 13^{20}. Reasons for changes in local time (East-West travel or change between standard time and daylight saving time) should be noted also in "Comments" column, on line where first measurements after change are recorded.

Each day do first set of measurements at time of arising, just after voiding bladder and before eating or activity. This should be followed by 8 or more sets of tests at intervals of about one and one-half hours (± ½-hour), with the last set just before retiring. Times of arising and retiring should be recorded in "Lights-on-off" column even if, for some reason, measurements are not taken.

If urine is to be collected, do this first and then proceed with measurements as follows, recording observations in appropriate columns of sheet. Each set of measurements should be entered on a new horizontal line. Always try to do a complete set of measurements, but if this is not possible measure what time allows. Abbreviations used in column headings are indicated below in parentheses after the full name of variable.

1. Site selection: sit down comfortably, at a table if possible, away from distractions.

2. Time Code: At start of measurement record month (Mo.), day in columns 1,2 and record hour, minute (HrMin) in local time under column 3.

3. Oral Temperature (oral Temp.): Shake thermometer so mercury column reads below 96° and place as far back as comfortable under tongue. Thermometer should remain in position in closed mouth for 5 or more minutes while you remain seated and take several other measurements as follows:

4. Mood and Vigor Ratings (M and V): Rate yourself for mood and physical vigor using the following scale adjusted to your own subjective range, with the middle value "4" representing your usual, average daily feeling:

MOOD		PHYSICAL VIGOR
Depressed, "blue"	1	Inactive, tired
Somewhat depressed	2	Somewhat tired
Slightly less cheerful than usual	3	Slightly less active than usual
Usual state	4	Usual State
Slightly more cheerful than usual	5	Slightly more active than usual
Quite cheerful	6	Quite active
Happy, elated	7	Active, full of pep

5. Pulse (Pls/Min): Count heartbeats at wrist (or neck (carotid artery) or chest, whichever is most accessible)) for 1 minute (timed with stopwatch).

6. Blood pressure (Blood Press-Syst. and Diast.): This measure will require practice before it represents accurate pressures. Avoid any posture changes from start of the measurement session. Verify that the manometer needle, with the valve open, is within the boundary of the zero mark. Wrap the cuff snugly, but without pressure, around the upper arm. The distal end of the cuff should be at least one inch above the bend of the elbow. If the cuff has a built-in or attached stethoscope, its pick-up should rest above the brachial artery on the inside of the arm with the cuff positioned as explained. Indicate under "Comments" (sheet 1) the arm bearing the cuff. Avoid changing the arms, but if such change is made, indicate under "Comments" when and why the alternate arm was used.

The forearm should be extended and kept relaxed on a horizontal surface preferably at heart level, (i.e., the fourth intercostal space at the sternum). Use temporary means if necessary to maintain the entire length of the forearm at the required level. The level should not change from one session to the next. Keep the arm completely relaxed.

Place earpieces of the stethoscope in ears, close the manometer valve and, using free hand, pump the pressure rapidly to approximately 160 mm Hg or 20 mm Hg above the highest expected systolic pressure.

If beats are heard, inflate the cuff at least 30 mm Hg higher and listen again. If beats are no longer heard, partially open exhaust valve to let the pressure drop slowly at the constant rate of 3–4 min Hg/sec. (2 mm Hg/heartbeat). This will have to be practiced. Your systolic pressure corresponds to the manometer reading when you first hear a beating K (Korotkoff) sound. Mentally make a note of this reading, but continue to watch the dial as the pressure is released at the same rate. Diastolic pressure I is noted whenever the K-sounds become muffled, i.e., undergo a quality change. Diastolic II reading is taken when the K-sounds have just disappeared, whether or not they became muffled earlier. The cuff can now be deflated rapidly by completely opening exhaust valve. Record all three pressure readings in the sequence of their measurement, the two diastolic pressures being separated by a diagonal line, e.g., 72/70. If the K-sounds disappear without prior muffling, Diastolic I and II should be recorded the same, e.g., 72/72. For

best accuracy try to obtain all three pressure readings in one approach, with only one pressurization. Until you become experienced in listening to the beating sounds it may be best to concentrate on the scale point where the beating disappears completely – Diastolic II – and record only systolic and Diastolic II.

7. Finger Counting (Fngr Cntg): Hold stopwatch in left hand (set to zero). Raise right hand, palm upward, elbow flexed to allow for good vision of fingers. Start watch and immediately touch right index finger with right thumb and silently count "1"; then touch thumb to second finger and count "2"; continue these movements and counts to the 3rd and 4th fingers, and back and forth to fingers 3,2,1 and 2,3,4, respectively as fast as possible, until the count of "25" is reached. On the 25th count, check the correctness of the count by whether the thumb is touching the index finger. Immediately repeat the count 1–25 as above and stop the watch upon reaching the second count of "25". Record the elapsed seconds to the nearest 0.1 second. This performance test serves as one of several approaches to approximating eye-hand coordination.

8. Adding speed (Add. Speed): Refer to Random Number Addition Tables provided (Appendix E–3). Enter I.D. No. and consecutive sheet number in spaces provided at the top of each sheet. Start stopwatch (face down) and as quickly as possible, accurately add consecutive pairs of digits in left-most single column of 50 random numbers – entering each pair-sum between and to the right of the digits. For example, for a column with the digits 7,1,5,2,9, etc., the first sum would be 7 + 1 = 8, the next sum 1 + 5 = 6, the third 5 + 2 = 7, etc. After last addition at bottom of column, stop watch and record elapsed time to the nearest 0.1 second at bottom of column. Then count the number of errors and record in the "Adding" column of the self-measurement recording sheet the ratio of the number of correct sums to the elapsed time in seconds.

9. Temperature should now be recorded under "Oral-Temp" by reading the position of the mercury column on the calibrated scale to the nearest hundreth.

10. Dynamometry (Strength-Rt + Lft): Turn needle-follower on dynamometer to zero before doing each test. Stand up and assume a stance with eyes forward, shoulders back and feet about a foot apart. With dynamometer held in right hand, extend arm downward at about 30° angle from body and squeeze quickly with full effort. Release grip and record value indicated by needle-follower. Repeat with left hand.

11. Tapping Task (Tapping): See separate sheet for instructions (Appendix E–4).

12. Body Weight (Body Wt.): Use a physician's scale to measure your body weight in the nude and record it to nearest 1/8 lb in the last column.

The above procedure is a modified version of that described in "Autorhythmometry – Procedures for Physiologic Self-measurements and their Analysis" by F. Halberg, E. A. Johnson, W. Nelson, W. Runge and R. Sothern. *The Physiology Teacher,* 1972, 1, 3–11.[54]

Appendix E-2

Please return to: Chronobiology Laboratories, 380 Lyon Labs, University of Minnesota, Mpls., Minn., USA 55455 (612-373-2916)

Self-measurement Recording Sheet

Subject I.D. Number:_____ ; Age:_____ ; Sex: M F ; Consecutive Sheet Number:_____.

Yr:					Pls	Blood Press		Fngr	Adding	Tapping	Strength		Oral	Lights:		Body	
Mo.	Day	HrMn	M	V	Min	Syst	Diast	Cntg	(ratio)	(ratio)	Rt	Lft	Temp	On	Off	Wt.	Comments:

Appendix E-3

Chronobiology Laboratories, 380 Lyon Labs, University of Minnesota, Mpls., Minn., USA

Random Number Addition -- Performance Test -- Side A

Subject Identification________________________________ Page No.________

6	6	6	9	7	4	7	0	7	8	3	3	1	7	5	9	7
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4	9	5	7	2	5	2	8	0	9	8	2	5	3	5	2	2
6	9	0	4	9	9	6	9	6	1	8	7	6	6	3	0	6
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4	5	1	9	8	1	7	8	8	9	2	2	7	7	0	0	6
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7	7	9	6	5	6	3	6	1	0	3	4	0	5	6	2	1
6	3	5	5	0	9	7	7	4	9	0	4	6	8	8	0	2
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secs																	

Random Number Addition -- Performance Test -- Side B

Subject Identification____

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																	SECS

Chronobiology Laboratories, 380 Lyon Labs, University of Minnesota,Mpls.,Minn.,USA

Random Number Addition -- Performance Test -- Side C

Subject Identification______________________________Page No.________

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8	4	5	4	6	6	7	2	6	1	9	5	8	7	7	1	7
0	0	9	0	8	9	9	7	5	7	5	4	6	1	1	9	6
6	3	0	2	3	1	9	2	9	6	2	6	1	7	7	3	1
4	1	8	3	9	5	5	3	8	2	1	7	2	6	7	7	0
0	9	4	3	7	8	0	3	8	7	0	2	6	7	3	0	6
5	3	2	2	1	7	0	4	1	0	2	7	4	1	2	2	2
0	2	3	9	6	8	5	2	3	3	0	9	1	0	0	6	7
1	6	8	8	2	9	5	5	9	8	6	6	6	4	8	5	8
0	3	7	8	8	9	7	5	9	9	7	5	8	6	7	2	8
0	7	1	7	7	4	4	1	6	5	3	1	6	6	3	5	2
2	0	8	3	3	3	7	4	8	7	5	3	9	0	8	8	7
2	3	4	8	2	2	8	6	3	3	7	9	8	5	7	8	1
3	4	7	6	1	9	5	3	1	5	2	6	7	4	3	3	9
3	5	6	6	3	5	2	9	7	6	1	2	8	1	8	6	4
0	3	1	1	6	0	3	6	5	9	4	6	5	3	3	5	7
0	7	5	3	3	9	4	9	4	2	6	1	4	2	9	2	9
9	7	0	1	9	1	8	2	8	3	1	6	9	8	9	5	0
4	7	3	2	3	1	8	3	7	9	9	4	2	4	0	2	0
5	6	6	2	3	3	4	4	4	2	3	4	9	9	4	4	8
1	3	7	4	7	0	7	0	1	1	4	7	3	6	0	9	2
9	5	8	1	8	0	6	5	3	2	9	6	0	0	7	4	1
0	5	3	6	4	0	9	8	3	2	3	2	9	9	3	8	7
5	4	1	6	0	0	1	1	1	3	3	0	7	5	8	6	6
1	5	9	1	7	0	6	2	5	3	1	9	3	2	2	5	8
3	8	4	5	5	7	6	2	0	5	2	6	6	6	0	6	0
4	9	7	6	8	6	4	6	7	8	1	3	8	6	6	6	4
5	9	1	9	6	4	0	9	9	4	1	3	1	1	2	2	5
0	9	4	7	4	7	9	7	3	9	9	3	7	4	0	8	5
4	8	5	0	9	2	3	9	2	9	2	7	4	8	2	4	3
5	4	7	6	8	5	2	4	4	3	5	1	5	9	3	1	4
7	5	1	5	7	2	6	0	6	8	9	8	0	0	5	3	1
3	9	1	5	4	7	0	4	8	3	5	5	8	8	6	5	0
1	2	2	5	9	6	0	3	1	5	2	1	9	1	2	1	3

secs																	

Random Number Addition -- Performance Test -- Side D

Subject Identification____

3	8	8	4	9	2	9	9	3	8	2	1	4	4	5	4	0
4	5	0	4	2	0	0	9	4	9	8	9	7	7	7	4	5
4	3	9	3	4	1	3	2	2	1	9	0	7	8	5	6	7
0	8	3	0	9	3	4	4	7	7	4	4	0	7	4	8	6
8	3	8	2	8	7	8	8	0	6	5	3	3	4	4	3	7
2	8	5	9	7	2	0	4	0	5	9	4	2	0	5	2	6
0	3	8	0	2	2	8	8	8	4	8	8	9	3	2	7	6
4	9	9	9	8	7	4	8	6	0	5	3	0	4	5	1	3
2	7	8	4	0	2	2	8	4	6	1	7	8	2	0	3	3
7	1	0	2	6	8	7	8	2	1	2	1	6	9	9	3	7
3	5	9	0	2	9	1	3	8	6	4	4	3	7	2	1	2
5	4	8	6	6	5	7	4	1	1	4	0	1	4	8	7	3
4	8	1	3	7	2	2	0	4	1	8	4	9	8	4	5	3
4	7	4	6	8	5	0	5	2	3	2	6	3	4	6	7	2
7	5	8	3	0	0	7	4	8	1	0	6	4	3	4	5	0
1	9	3	2	5	8	1	5	4	9	4	6	3	5	2	3	2
3	0	4	9	6	9	2	4	8	9	3	4	6	0	4	5	7
3	0	5	0	7	5	2	1	6	1	3	1	8	3	1	8	4
5	5	1	4	4	1	3	7	0	9	5	1	1	1	0	8	6
7	9	6	2	9	4	1	4	0	1	3	3	1	7	9	2	2
5	9	7	4	8	6	7	2	7	7	7	6	5	0	3	3	0
4	5	1	3	3	9	6	6	3	7	7	5	4	4	5	2	3
7	0	1	0	8	3	3	7	5	6	3	0	3	8	7	3	4
1	5	1	6	5	2	0	6	9	6	7	6	1	1	6	5	1
4	9	9	8	9	3	0	2	1	8	1	6	8	1	6	1	5
5	7	2	7	5	3	6	8	9	8	8	1	3	0	4	4	8
8	5	8	5	6	8	6	5	2	2	7	3	7	6	9	2	2
8	5	2	5	5	8	6	6	8	8	4	4	8	0	3	5	7
8	4	2	0	8	5	7	7	3	1	5	6	7	0	2	8	9
4	2	4	3	2	6	7	9	3	7	5	9	5	2	2	0	0
0	1	1	5	9	6	3	2	6	7	1	0	6	2	2	4	2
8	3	9	1	1	5	6	3	3	8	4	9	2	4	9	0	8
4	1	5	9	3	6	1	4	3	3	5	2	1	2	6	6	1
6	5	5	5	8	2	4	7	6	4	1	8	6	2	2	8	3
5	3	1	7	0	4	9	2	6	9	4	4	8	2	9	7	1
3	9	9	0	4	0	2	1	1	5	5	9	5	8	9	4	8
9	0	6	7	6	6	8	2	1	4	1	5	7	5	4	9	9
7	6	7	0	4	0	3	7	7	7	6	1	3	1	9	0	4
1	9	8	8	1	5	2	0	0	0	8	0	2	0	5	5	7
4	9	1	4	0	9	9	6	2	7	7	4	8	2	5	7	5
5	0	8	1	6	9	7	6	1	6	3	8	6	8	8	3	1
2	4	8	6	4	5	1	3	4	6	3	5	4	5	5	9	8
4	0	4	7	2	0	5	9	4	3	9	4	7	5	1	6	4
8	0	4	3	8	5	2	5	9	6	9	3	2	5	1	6	0
3	0	1	8	8	9	7	0	0	1	4	1	5	0	2	1	3
4	1	2	9	0	6	7	3	1	2	7	1	8	5	7	1	5
5	9	5	7	6	8	9	7	1	1	1	3	0	4	6	5	6
2	5	1	0	7	6	2	9	3	7	2	3	9	3	3	2	3
9	5	0	5	8	7	0	0	1	1	1	9	9	2	7	8	0
4	2	6	3	4	0	1	8	4	7	7	6	5	6	2	2	8

																	Secs

Appendix E–4

INSTRUCTIONS FOR TAPPING TASK

We would like you to perform the tapping task as one of your regular self-measurements and enter your scores on the self-measurements data sheet. You will be provided with a supply of tapping task sheets which consist of a single sheet of paper with two parallel columns of small circles. Each time you perform the task you will take one of these sheets of paper, a stopwatch, and the felt-tip pen provided and do the following:

> As soon as you start the stopwatch with your non-dominant hand, begin with the pen in the other hand to strike inside each target circle going as fast as you can from left to right down the page. Strike at each circle only once. Score as many "hits" as you can. If you hit outside the circle an error will be recorded. **Emphasize accuracy rather than speed.** Stop the watch as soon as you finish striking at the last circle.

Record at the top of the sheet both the total elapsed time in seconds and the number of errors. These numbers should also be placed in the appropriate columns on the self-measurement data sheet. Hand in the tapping task sheet when you hand in your daily food log.

TAPPING TASK

Score:

Time _______ sec.

Errors _______

Name: ______________________________

Date: ____________

Time: ____________

Score:

Time _______ sec.

Errors _______

TAPPING TASK

Name: ____________________ Date: __________

Time: __________

Appendix E–5

APPLIED PHYSIOLOGY RESEARCH LABORATORY
Kent State University
Kent, Ohio 44242

CIRCADIAN RHYTHM QUESTIONNAIRE

(This questionnaire was constructed by Dr. O. Ostberg and Dr. J. Horne, Loughborough University of Technology, Loughborough, England and is being used with their kind permission.)

This experimental questionnaire aims to ascertain your body's own natural daily rhythm of behavior and activity.

Please read each question VERY CAREFULLY before answering.

Try and answer the question as honestly as possible. No one except the research staff will ever see your answers.

Most of the questions have a selection of answers. For each question place a check or cross alongside ONE answer only. Some questions have a scale instead of a selection of answers. Place a check or cross at the appropriate point along the scale.

Answer every question.

Answer each question in the order it appears.

Each question should be answered independently of the others. Do not go back and check your answers.

Please feel free to make comments about any question in the section provided below the appropriate question.

THANK YOU.

NAME____ DATE_______________

SEX (M or F)_______________

OCCUPATION____

Do you work shifts? (yes or no) _______________

1. When would you usually get up in the mornings if you were entirely free to plan your day and did not have to take into consideration anything but your own "feeling best" rhythm?

   Place a cross at the appropriate point along the time scale

AM 6 7 8 9 10 11 12

   COMMENTS:

2. When would you usually go to bed at night if you were entirely free to plan your day and did not have to take into consideration anything but your "feeling best" rhythm?

   Place a cross at the appropriate point along the time scale

PM 9 10 11 12 1 AM 2 3

   COMMENTS:

3. During the FIRST HALF HOUR after having woken up in the morning, how does your behavior usually function?

   Does not function at all

   Does not generally function too well

   Generally functions reasonably well

   Functions well

   COMMENTS:

4. On working or study days, to what extent are you dependent on being woken up by an alarm clock, member of the family, etc.?

   Not at all dependent on being woken

   Sometimes " " " "

   Often " " " "

   Always " " " "

   COMMENTS:

5. During the FIRST HALF HOUR after having woken up in the morning, how is your appetite usually?

Have a very good appetite

Have a fairly good appetite

Have a fairly poor appetite

Have a very poor appetite

COMMENTS:

6. How easy do you usually find it getting up in the mornings?

Have great difficulty getting up

Have some difficulty getting up

Seldom have difficulty getting up

No difficulty at all

COMMENTS:

7. When do you usually get up on week-end mornings compared with week days?

Place a cross at the appropriate point along the time scale

0	1	2	3	4	5	6

Hours Later

COMMENTS:

8. How do you usually feel most nights when going to bed?

Very tired

Fairly tired

A little tired

Not tired

COMMENTS:

9. During the last TWO WEEKS, how often have you lingered around in the evenings without doing much and consequently felt that you have been getting too little sleep?

Has not happened

Has happened once

Has happened two or three times

Has happened several times

COMMENTS:

10. Suppose that you have applied for a good job and that you have been called for interview. All the candidates are equally qualified and so the final decision will be made at the interview. You have been asked to turn up at 8 am. How do you think you could perform at this time of the day, considering that you really want to do well?

No problem, would be on good form

Would be in reasonably good form

A bit early, would have to put in some extra effort

Far too early, would have to put in a lot of extra effort

COMMENTS:

11. Suppose that this interview has now been rescheduled for 9:00 pm. How do you think you could perform at this time of the day, considering that you really want to do well?

No problem, would be on good form

Would be in reasonably good form

A bit late, would have to put in some extra effort

Far too late, would have to put in a lot of extra effort

COMMENTS:

12. During the FIRST HALF HOUR after having woken in the mornings, how tired to you **generally** feel?

Feel very tired

Feel fairly tired

Feel fairly rested

Feel very rested

COMMENTS:

13. During the last TWO WEEKS how often have you got up later than planned, even though you went to bed at your right time, and hence had difficulty in getting ready on time?

Has not happened

Has happened once

Has happened two or three times

Has happened several times

COMMENTS:

14. When you have no commitments the next day, at what time do you **usually** go to bed, compared with your usual bed time?

Seldom or never later

Not more than one hour later

Between one and two hours later

More than two hours later

COMMENTS:

15. Which of the following (working day and weekend) daytime coffeebreaks do you think you are **usually in most need of**?

Mid-morning

Mid-afternoon

COMMENTS:

16. Suppose that you have decided to engage in some physical exercise. Your friend suggests that you do this together for ONE HOUR TWICE A WEEK and that the best time for him was between 7:30 and 8:30 AM. You know from experience that you will have to be on fairly good form in order to keep up. How do you feel about this time of day, bearing in mind that you do not have to take into consideration anything but your own "feeling best" rhythm?

Yes, would be on good form

Fair enough, would be in reasonably good form

A bit early, would find it a little difficult

No, would definitely find it very difficult

COMMENTS:

17. At what time in the evening do you usually start feeling tired and in need of sleep?

Place a cross at the appropriate point along the time scale

PM 8 9 10 11 12 1 2 3 AM

COMMENTS:

18. Suppose that you are to take part in a test that is going to be mentally exhausting and you want to perform well. The test lasts for two hours and it will be very trying and therefore you will have to be at your peak. There are four times of testing for you to choose from. Which one would you prefer if you were entirely free to plan and do not have to take into consideration anything but your own "feeling best" rhythm?

8:30 – 10:30 AM	4:30 – 6:30 PM
10:30 – 12:30	6:30 – 8:30

COMMENTS:

19. Suppose that for some reason you have gone to bed several hours later than usual, but on the other hand there is no need to get up at any particular time the next morning. Which of the following events are you most likely to experience?

Will wake up at the usual time and will not be able to fall asleep again

Will wake up at the usual time and will be able to dose thereafter

19. Will wake up at the usual time but will surely fall asleep again

Will not wake up until several hours later than the usual time

COMMENTS:

20. Suppose that for one night you have to remain awake between 3:30 and 5:30 am in order to carry out a night watch. You have no commitments the following day. Which of the following alternatives would suit you best?

Would not go to bed at all until the watch was over

Would take a nap before the watch and then sleep after

Would take a good sleep before the watch and then a nap after

Would take all my sleep before the watch and not sleep after

COMMENTS:

21. Suppose that you have to do about two hours of hard PHYSICAL work one day. There are four times to choose from. Which one would you prefer if you were entirely free to plan your day and do not have to take into consideration anything but your own "feeling best" rhythm?

8:30–10:30 am   10:30–12:30 am   4:30–6:30 pm   6:30–8:30 pm

COMMENTS:

22. Suppose that you have decided to engage in some physical exercise. Your friend suggests that you should do this together for ONE HOUR TWICE A WEEK and that the best time for him was between 9:00 pm and 10:00 pm. You know from experience that you will have to be on fairly good form in order to keep up. How do you feel about this time of day, bearing in mind that you do not have to take into consideration anything but your own "feeling best" rhythm?

Yes, would be on good form

Fair enough, would be in reasonably good form

A bit late, would find it a little difficult

No, would definitely find it very difficult

COMMENTS:

23. Suppose that you were able to choose your own working hours. Assume that you worked a SIX hour day (including breaks) and that your job was interesting and well paid BY RESULTS. You may select any SIX consecutive hours.

Each box represents one hour. Check the SIX consecutive hours

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

midnight AM noon PM midnight

COMMENTS:

24. At what time of the day do you think you reach your "feeling best" peak?

Place ONE cross at the appropriate point along the time scale.

Each box represents an hour of the day.

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

midnight AM noon PM midnight

COMMENTS:

25. **Ideally**, how much sleep do you think you need each night?

Place a cross at the appropriate point along the time scale.

HOURS 5 6 7 8 9 10 11

COMMENTS:

26. In the weekday mornings, how much dosing time do you **generally** spend between awakening and sitting up in bed?

Place a cross at the appropriate point along the time scale.

MINUTES 0 5 10 20 25 30 35 40 Longer

COMMENTS:

27. On weekends and days off, how much time dozing do you generally spend between awaking and sitting up in bed?

Place a cross at the appropriate point along the time scale.

MINUTES 0 5 10 20 25 30 35 40 Longer

COMMENTS:

28. After lying down in bed, about how long does it generally take you to fall asleep?

Place a cross at the appropriate point along the time scale.

MINUTES 0 5 10 20 25 30 35 40 Longer

COMMENTS:

29. On working and/or school days, which is your usual main meal of the day?

Breakfast

Lunch

Evening meal

COMMENTS:

30. On weekends and days off, which is your usual main meal of the day?

Breakfast

Lunch

Evening Meal

COMMENTS:

31. One sometimes hears about "feeling best in the mornings" and "feeling best in the evenings" types of people. Which of these types do you regard yourself to be?

Definitely a "morning" type

Rather more a "morning" than an "evening"

Rather more an "evening" than a "morning" type

Definitely an "evening" type

COMMENTS:

GENERAL COMMENTS ABOUT THIS QUESTIONNAIRE

Appendix F. Physiological, Biochemical, and Body Weight Data

1. Ad libitum group cosinors.

2. Individual body weight changes in pounds and percentages.

3. Linear regression analysis of weight changes.

Table F-1. Mean Cosinor Summary Results for *Ad Libitum* Control (C) and *Ad Libitum* (Stage IV) Experimental (E) Subjects

Variable Measured	Units	Group	Group P	Proportion of Individuals $P < 0.05$	Mesor	Amplitude (95% CI)	Acrophase (95% CI)
Vital Signs							
Temperature (oral)	°F	C	< 0.001	16/17	98	0.46 (0.37,0.55)	-208°(-199,-218)
		E	< 0.001	16/18	98	0.44 (0.29,0.60)	-203°(-187,-224)
Radial Pulse	beats/min.	C	< 0.001	12/17	70	5.5 (2.4 ,8.7)	-198°(-165,-237)
		E	< 0.003	9/18	72	4.1 (1.4 ,6.9)	-192°(-160,-228)
BP - systolic	mmHg	C	< 0.001	12/17	112	3.5 (1.8 ,5.4)	-207°(-194,-238)
		E	< 0.001	9/18	115	3.1 (1.3 ,4.9)	-205°(-182,-236)
BP - diastolic	mmHg	C	0.011	6/17	72	2.6 (0.6 ,4.6)	-193°(-159,-233)
		E	0.033	3/18	72	2.1 (0.2 ,4.1)	-178°(- 95,-224)
Psychological							
Mood	1-7 Scale	C	< 0.001	11/17	3.8	10.3 (4.4 ,16.7)	-184°(-144,-205)
		E	< 0.001	8/18	3.9	9.0 (4.2 ,14.8)	-165°(-119,-189)
Vigor	1-7 Scale	C	< 0.001	14/17	3.3	16.7 (7.8 ,26.2)	-169°(-142,-183)
		E	< 0.001	15/18	3.4	23.3 (13.6,33.0)	-162°(-140,-179)
Performance							
Tapping	No. Correct/ sec.	C	< 0.001	12/17	1.72	4.6 (3.1 ,6.1)	-173°(-160,-185)
		E	< 0.001	10/18	1.83	4.0 (2.0 ,5.9)	-183°(-156,-208)
Finger Counting[a]	Sec.	C	< 0.001	11/17	7.2	4.4 (2.3 ,6.5)	-182°(-165,-193)
		E	< 0.001	6/17	7.8	4.0 (1.8 ,6.2)	-192°(-175,-214)

[a] Cosinor computations based on secs. required for task completion, then acrophase shifted 180° to correspond to time of fastest performance.

Table F-1. (Continued)

Variable Measured	Units	Group	Group P	Proportion of Individuals P < 0.05	Mesor	Amplitude (95% CI)	Acrophase (95% CI)
Performance							
Addition	No Correct/ sec.	C	<0.001	11/17	1.56	4.7 (2.6 ,6.8)	-181°(-163,-194)
		E	< 0.001	7/18	1.52	3.5 (1.6 ,5.4)	-190°(-164,-213)
Rt. Grip	Relative Units	C	< 0.001	14/17	41	6.6 (4.4 ,8.9)	-198°(-188,-212)
		E	< 0.001	13/18	45	7.3 (3.5 ,11.2)	-193°(-179,-213)
L. Grip	Relative Units	C	< 0.001	14/17	36	6.7 (4.6 ,8.8)	-195°(-181,-209)
		E	< 0.001	12/18	40	8.1 (3.8 ,12.5)	-191°(-180,-214)
Blood[b]							
Insulin	μ units	C&E	< 0.001	N=34	25.9	31.5(18,45)	-273°(-247,-296)
STH	nano g/ml	C&E	0.005	N=34	3.7	40 (11,70)	-37 °(-358,-80)
Cortisol	μ g%	C&E	< 0.001	N=34	13.1	42 (33,51)	-142°(-130,-154)
Iron	μ g%	C&E	< 0.001	N=34	91	12.9(7.2,18.8)	-182°(-144,-215)
Lymphocytes	cells/mm^3	C&E	< 0.001	N=34	26.8	16.7(11.7,21.9)	-11 °(-353,-27)
WBC	cells/mm^3	C&E	< 0.001	N=34	7.1	9.7 (6.9,12.6)	-354°(-337, -7)
Chloride	mEq/1	C&E	< 0.001	N=30	102	0.79(0.37,1.21)	-110°(-67, -152)
BUN	mg%	C&E	0.002	N=34	17.1	3.8 (1.3, 6.6)	-348°(-298,-20)

[b] Data from control subjects and experimental subjects during Stage IV pooled for analysis.

Table F–2a. Individual Body Weight Changes[a] During Ad Libitum Stage IV Before Mealtime Restriction.

				Minimum[b]	Weight Before Stage IV			Weight Before Stage V				
				Desirable	Actual	Excess		Actual	Change		Excess	
I.D.	Sex	Age	Hgt.	Weight (lbs)	lb	lb	%	lb	lb	%	lb	%
2	M	35	5'6"	128	153	25	20%	151	−2	−1%	23	18%
5	M	58	5'7"	132	133	1	1	133	0	0	1	1
51	M	28	6'2"	160	170	10	6	170	0	0	10	6
54	M	22	6'0"	152	——	N/A	N/A	143	N/A	N/A	N/A	N/A
58	F	21	5'6"	118	159	41	35	158	−1	−1	40	34
59	F	19	5'7½"	122	135	13	11	131	−4	−3	9	7
64	M	17	5'10"	144	133	N/A	N/A	134	+1	+1	N/A	N/A
66	F	19	5'5"	112	115	3	3	114	−1	−1	2	2
72	F	19	5'8"	124	132	8	6	131	−1	−1	7	6
	Average				141.2			140.56	−1.0	−0.8		
4	M	34	5'6½"	130	184	54	42	183	−1	−1	53	41
53	M	19	5'4"	121	140	19	16	136	−4	−3	15	12
61	F	54	5'9"	134	143	9	7	146	+3	+2	12	9
62	M	19	5'11"	148	191	43	29	188	−3	−2	40	27
68	F	35	5'1"	105	106	1	1	103	−3	−3	N/A	N/A
69	F	39	5'2"	108	116	8	7	115	−1	−1	7	6
70[c]	M	21	5'10"	144	164	20	14	166	+2	+1	22	15
	Average				149.1			148.1	−1.0	−1.0		
3	F	38	5'6"	122	169	47	39	166	−3	−2	44	36
6	M	32	6'0"	152	167	15	10	168	+1	+1	16	11
56	F	19	5'8"	124	155	31	25	156	+1	+1	32	26
63	M	20	6'4"	168	154	N/A	N/A	153	−1	−1	N/A	N/A
70	M	21	5'10"	144	167	23	16	164	−3	−2	20	14
	Average				162.4			161.4	−1.0	−0.6		

[a]Based on body weight measures taken soon after waking and before first meal.

[b]Based on lowest desirable weight for appropriate age, sex and height, Metropolitan Life Ins. Tables, 1959.

[c]Subject repeated Stages V and VI on single meal regime after completing as ad lb. control.

Table F-2b. Individual Body Weight Changes[a] During Mealtime Restriction Stage V.

Subject	Single Meal Regime	Weight After Stage V: Actual lb	Change lb	Change %	Excess[b] lb	Excess[b] %	% Excess Lost/Gained
2	B	147	- 4	- 3	19	15	- 17
5	B	129	- 4	- 3	0	0	-400
51	B	158	-12	- 7	0	0	-120
54	B	140[d]	- 3	- 2	N/A	N/A	N/A
58	B	157	- 1	- 1	39	33	- 3
59	B	122	- 9	- 7	0	0	-100
64	B	130	- 4	- 3	N/A	N/A	N/A
66	B	113	- 1	- 1	1	1	- 50
72	B	121	-10	- 8	0	0	-125
	Average	135.2	- 5.3	- 3.9			
4	D	181	- 2	- 1	51	39	- 4
53	D	133	- 3	- 2	12	10	- 20
61	D	141	- 5	- 3	7	5	- 42
62	D	184	- 4	- 2	36	24	- 10
68	D	100[d]	- 3	- 3	N/A	N/A	N/A
69	D	110	- 5	- 4	2	2	- 71
70[c]	D	163	- 3	- 2	19	13	- 14
	Average	144.6	- 3.6	- 2.4			
3	A	166	0	0	44	36	0
6	A	167	- 1	- 1	15	10	- 6
56	A	155	- 1	- 1	31	24	- 3
63	A	157[d]	+ 4	+ 3	N/A	N/A	N/A
70	A	165	+ 1	+ 1	21	15	+ 5
	Average	162.0	+ 0.6	+ 0.4			

[a]Based on body weight measures taken soon after waking and before first meal.

[b]Based on comparison with lowest desirable weight for appropriate age, sex and height, Metropolitan Life Insurance Tables, 1959.

[c]Subject repeated Stages V and VI on single meal regime after completing as *ad lib*. control.

[d]Subject weighed less than minimum desirable weight at beginning of Stage V.

Table F-2c. Individual Body Weight Changes[a] During Mealtime Restriction Stage VI.

Subject	Single Meal Regime	Weight After Stage VI: Actual lb	Change lb	Change %	Excess[b] lb	Excess[b] %	% Excess Lost/Gained
2	D	145	- 2	- 1	17	13	- 11
5	D	130[d]	+ 1	+ 1	N/A	N/A	N/A
51	D	160[d]	+ 2	+ 1	N/A	N/A	N/A
54	D	148	+ 8	+ 6	N/A	N/A	N/A
58	D	157	0	0	39	33	0
59	D	124	+ 2	+ 2	2	2	N/A
64	D	132[d]	+ 2	+ 2	N/A	N/A	N/A
66	D	116	+ 3	+ 3	4	3	+300
72	D	121[d]	0	0	N/A	N/A	N/A
	Average	137.0	+ 1.8	+ 1.6			
4	B	171	-10	- 6	41	32	- 20
53	B	129	- 4	- 3	8	7	- 33
61	B	130	-11	- 8	0	0	-157
62	B	176	- 8	- 4	28	19	- 22
68	B	90[d]	-10	-10	N/A	N/A	N/A
69	B	106	- 4	- 4	0	0	-200
70[c]	B	158	- 5	- 3	14	10	- 26
	Average	137.1	- 7.4	- 5.4			
3	A	167	+ 1	+ 1	45	37	+ 2
6	A	168	+ 1	+ 1	16	11	+ 7
56	A	156	+ 1	+ 1	32	26	+ 3
63	A	158[d]	+ 1	+ 1	N/A	N/A	N/A
70	A	166	+ 1	+ 1	22	15	+ 5
	Average	163.0	+ 1.0	+ 1.0			

[a]Based on body weight measures taken soon after waking and before first meal.
[b]Based on comparison with lowest desirable weight for appropriate age, sex and height, Metropolitan Life Insurance Tables, 1959.
[c]Subject repeated Stages V and VI on single meal regime after completing as *ad lib*. control.
[d]Subject weighed less than minimum desirable weight at beginning of Stage VI.

Appendix F—3

Table F—3. Linear Trend-Line Regression Slopes of Weight Change During Restricted Mealtiming.

Subject	Rate of Weight Change (lb / wk)		ANOVA of Slopes		
Breakfast 1st:	Breakfast	Dinner	df	F	p
2	-1.532	-0.983	1,242	155.24	<0.001
5	-0.763	-0.134	1,36	5.88	<0.001
51	-2.755	-0.067	1,201	178.17	<0.001
54	-0.890	2.352	1,95	49.03	<0.001
58	Not available				
59	-2.570	-0.252	1,111	111.42	<0.001
64	-0.084	0.302	1,116	3.19	n.s.
66	-0.689	1.546	1,76	42.98	<0.001
72	-2.352	-0.672	1,151	94.48	<0.001
Dinner 1st:					
1†	0.005	-0.046	1,58	0.03	n.s.
4	-3.546	-0.596	1,33	150.97	<0.001
53	-1.596	-0.302	1,79	25.23	<0.001
61	-3.679	-1.394	1,90	106.30	<0.001
62	-1.798	-0.588	1,128	17.12	<0.001
68	-1.462	-0.941	1,123	9.79	<0.01
69	-1.075	-1.378	1,113	4.44	<0.05
70	Not available				

† Subject varied greatly from mealtime restriction guidelines during Stages V and VI.

Appendix G. Statistical Summaries

1. ANOVAs for SPSs before and after two weeks exposure to rations.
2. ANOVAs for first and second GPSs.
3. ANOVAs for SPSs before and after mealtiming restriction.
4. ANOVAs for GPSs before and after mealtiming restriction.
5. ANOVAs for effects of survey context on preference ratings.
6. ANOVAs for effects of mealtiming on nutrient consumption.

Appendix G–1

Table G-1. Analysis of Variance for Canned and Frozen Ration SPS Preference Tests Before and After Two Weeks Eating Exposure (Stage II or III).

A. Canned: SPS 7 vs. SPS 9 or 12

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	10	39.26	897.75		
Tests	1	22.43	889.32	2.46	13.73***
Food	24	11.70	319.73	4.69***	6.73***
S x T	10	9.10	64.77		
S x F	240	2.49	47.52		
T x F	24	0.87	13.39	0.65	0.80
S x T x F	240	1.33	16.73		

B. FROZ: SPS 8 vs. SPS 10 or 11

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	10	29.42	659.01		
Tests	1	2.20	144.12	0.25	1.38
Food	23	7.87	155.96	2.00**	2.08**
S x T	10	8.66	104.00		
S x F	230	3.93	74.99		
T x F	23	0.95	24.32	0.90	1.37
S x T x F	230	1.06	17.80		

**$p < 0.01$
***$p < 0.001$
Subjects analyzed - 51,53,54,55,56,57,58,59,61,62,63.

Appendix G-2

Table G-2. Analysis of Variance Summaries for 1st and 2nd GPS Preference Tests for Ration and Non-ration Foods.

A. Ration Foods: GPS 1 vs. GPS 17

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	8	15.42	446.88		
Tests	1	0.05	320.98	0.01	5.20
Food	23	10.57	136.96	2.87***	2.17**
S x T	8	3.24	61.72		
S x F	184	3.69	63.11		
T x F	23	1.62	42.76	2.64***	2.57***
S x T x F	184	0.61	16.63		

b. Non-Ration Foods: GPS 1 vs. GPS 17

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	8	188.27	6588.62		
Tests	1	82.68	2864.26	13.75**	8.34*
Food	264	13.06	250.05	3.93***	3.06***
S x T	8	6.01	343.41		
S x F	2112	3.32	81.63		
T x F	264	0.61	17.86	1.15	1.15
S x T x F	2112	0.53	15.54		

*p < 0.05
**p < 0.01
***p < 0.001

Subjects analyzed - 51, 53, 54, 56, 59, 61, 62, 64, 55

Appendix G-3

Table G-3. Analysis of Variance Summaries for MCI and Frozen Ration SPS Preference Tests Before and After Mealtiming Restriction.

A. MCI: SPS's 15, 18, and 20.

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	10	75.42	636.97		
Tests	2	10.65	2.70	2.38	0.06
Food	24	42.45	761.86	5.36***	7.04***
S x T	20	4.48	46.93		
S x F	240	7.92	108.21		
T x F	48	0.82	38.05	0.95	1.71**
S x T x F	480	0.86	22.25		

B. FROZ: SPS's 16, 19, and 21.

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	10	84.22	886.85		
Tests	2	2.55	34.28	0.82	0.61
Food	23	63.75	641.76	7.38***	7.32***
S x T	20	3.12	56.54		
S x F	230	8.64	87.70		
T x F	46	1.01	15.70	1.31	1.16
S x T x F	460	0.77	13.58		

** $p < 0.01$
*** $p < 0.001$

Subjects analyzed - 51, 53, 54, 59, 61, 62, 64, 66, 68, 69, 72

Appendix G–4

Table G-4. Analysis of Variance Summaries for GPS Preference Tests Before and After Mealtiming Restriction.

A. Ration Foods: GPS 17 vs. GPS 22

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	10	35.53	870.91		
Tests	1	0.16	7.73	0.09	0.10
Food	23	26.57	243.06	5.43***	3.33***
S x T	10	1.83	75.65		
S x F	230	4.89	73.02		
T x F	23	1.30	15.02	1.23	0.81
S x T x F	230	1.06	18.52		

B. Non-Ration Foods: GPS 17 vs. GPS 22

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	10	499.28	12341.53		
Test	1	104.40	1358.15	4.73	3.39
Food	265	17.74	273.83	3.81***	3.10***
S x T	10	22.06	400.51		
S x F	2650	4.66	88.40		
T x F	265	1.01	22.51	1.52**	1.30**
S x T x F	2650	0.66	17.38		

** $p < 0.01$
*** $p < 0.001$

Subjects analyzed - 51, 53, 54, 59, 61, 62, 64, 66, 68, 69, 72

Appendix G–5

Table G-5. Analysis of Variance Summary for Effects of Survey Context on Preference Ratings for Ration Foods.

Source	df	MS		F	
		Hedonic	Freq.	Hedonic	Freq.
Subjects	22	24.92	885.91		
Tests	1	15.30	1011.98	4.81*	7.18*
Food	21	26.92	227.24	6.38***	3.92***
S x T	22	3.18	140.84		
S x F	462	4.22	57.98		
T x F	21	2.08	48.35	3.36***	2.83***
S x T x F	462	0.62	17.08		

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Subjects analyzed: 2-6, 51, 53-59, 61-66, 68-70, 72.

Tests: SPS 5 + SPS 6 vs. GPS 1 (Ration Foods)

Appendix G–6

Table G-6. Analysis of Variance Summary for Effects of Mealtiming on Nutrient Consumption.

A. Control Ad Lib Group

Source	df	MS	F
Subjects	4	44937.33	
Phase	2	77.0577	0.0421
Nutrients	2	57002.18	6.7530
S x P	8	1829.414	
S x N	8	8441.007	
P x N	4	78.7343	0.3150
S x P x N	16	249.9420	

B. Ad Lib, Breakfast, Dinner Group

Source	df	MS	F
Subjects	8	12785.40	
Phase	2	13663.56	9.6685***
Nutrients	2	118791.2	70.9624
P x S	16	1413.202	
P x N	4	1778.044	7.0431***
S x N	16	1674.001	
P x S x N	32	252.4523	

C. Ad Lib, Dinner, Breakfast Group

Source	df	MS	F
Subjects	7	19855.53	
Phase	2	7338.087	8.3627***
Nutrients	2	96697.90	48.9995
P x S	14	877.4757	
P x N	4	1932.624	4.3180**
S x N	14	1973.447	
P x S x N	28	447.5717	

** $p < 0.01$
*** $p < 0.001$

Subjects analyzed - 1, 2, 4, 5, 51, 53, 54, 58, 59, 61, 62, 64, 66, 68, 69, 70',72
Control subjects - 3, 6, 56, 63, 70

Appendix H. Summary of Subjects' Written Comments Upon Completion of Study

Table H-1. Summary of Subjects' Written Comments Upon Completion of Study†

	51	54	59	61	62	64	66	68	69	72	TOTAL
1. What meal did you start with?											
Breakfast	X	X	X			X	X			X	6
Dinner				X	X			X	X		4
2. Did you choose to start on that schedule?											
Yes	X	X	X	X		X	X	X	X	X	9
Why? Wanted to get the worst over with	X	X	X								3
Wanted to save the worst/hardest for last				X			X	X	X		4
Prefers rising early										X	1
No earlier						X					1
No					X						1
3. Which meal time did you like most?											
Breakfast	X					X	X			X	4
Dinner		X	X	X	X			X	X		6
4. What time did you eat breakfast? (± 1 hour)											
0600								X	X		2
0800		X	X		X	X				X	5
1000	X						X				2
No answer				X							1
5. What time did you eat dinner? (± 1 hour)											
1800	X		X		X	X	X	X	X	X	8
2000		X									1
No answer				X							1
6. Did you differ from these meal times more than once?											
Yes	X	X	X		X	X	X	X	X		8
Explain Adjusted meal time to fit schedule	X	X	X			X	X				5
Ate breakfast later on weekends						X			X	X	3
No										X	1
No answer				X							1

The header "SUBJECT NO." is printed above the columns 51 to 72.

	51	54	59	61	62	64	66	68	69	72	TOTAL
7. Did you go off the diet at anytime?											
Yes	X		X			X				X	4
Explain: 2 Candy bars	X					X					2
½ Can non-diet soda (by accident)										X	1
4 Glasses of milk (for acid stomach)			X								1
No		X		X	X		X	X	X		6
8. What was easiest about eating Breakfast only?											
Nothing								X			1
Convenience, didn't have to prepare evening meal	X		X		X		X		X		5
Being satisfied/full/not hungry for the rest of the day	X					X	X			X	4
Weight loss	X										1
Luxury to eat a lot in the morning		X									1
No answer				X							1
9. What was difficult about eating Breakfast only?											
Hunger in evening	X	X	X	X				X		X	6
Food is unappealing/subject not hungry in A.M.		X		X	X			X			4
Had to get up early		X				X			X		3
Stuffed feeling after eating	X						X	X			3
Sleep disturbed (by hunger)		X						X			2
No ambition/run down								X			1
10. What was easiest about eating Dinner only?											
Went to sleep full/no disturbed sleep	X							X	X		3
Looked forward to eating			X					X		X	3
Fewer hungry evenings		X	X	X							3
Could eat leisurely		X				X		X			3
Had all day to plan/prepare meal		X						X			2
Could eat more	X				X						2
Food was more palatable							X				1

	51	54	59	61	62	64	66	68	69	72	TOTAL
11. What was difficult about eating Dinner only?											
Nothing		X						X			2
Felt "light-headed"/low energy level						X			X		2
Food quality/variety was poor									X		1
Hunger/thinking about food all day	X		X		X	X				X	5
Never got full enough							X				1
Finding time for meal			X								1
Took longer for full feeling to go away	X										1
Eating at proper time				X							1
Grouchy/irritable	X					X					2
12. Was it easy to eat once a day?											
No		X	X		X	X			X		5
Yes							X			X	2
It was easy to eat just dinner				X				X			2
It was fairly easy to eat just breakfast	X										1
What were the advantages?											
More free time	X		X	X			X	X		X	6
Weight loss			X						X		2
No answer		X			X						2
No advantage						X					1
13. What was difficult about eating once a day?											
Hunger	X	X	X		X				X		5
Attempting to eat enough at one time	X	X					X		X	X	5
Thinking about food incessantly							X	X		X	3
No nibbling/snacking				X		X					2

	51	54	59	61	62	64	66	68	69	72	TOTAL
14. Comments about physical well-being											
Tired/run down	X	X	X	X	X		X		X		7
Unpleasant bloated/stuffed feeling after meals			X				X				2
Stomach cramps			X								1
Constipation			X								1
Coordination disrupted		X							X		2
Dizzy									X		1
Difficulty sleeping									X		1
Fine										X	1
15. Comments on psychological well-being											
Depression	X		X				X	X		X	5
Loss of concentration			X				X				2
Felt socially odd/socially cut off	X		X				X	X			4
More irritable	X	X		X		X	X		X		6
Craved other foods									X		1
Memory loss	X		X								2
Loss of appetite	X										1
16. Additional comments											
Unhappy with menu	X		X						X	X	4
Because of study, now appreciates good food									X	X	2
Sociability/cooperation of subjects important aspect of study			X							X	2
Heightened awareness							X				1

†Includes all subjects who were administered questionnaire.

GLOSSARY*

ACROPHASE (θ, theta): a measure of a rhythm's timing; specifically, the lag from a defined reference point, of the crest time of the cosine function used to approximate a rhythm. Units: Angular measures (degrees, radians) or time units (seconds, minutes, hours, days, months, years). Angular measures are directly applicable to any cycle length and hence are more suitable for general use because of greater familiarity; degrees (with 360 = period of rhythm) are preferred over radians.

AD LIBITUM STAGES: stages of the experiment in which the participants have no restrictions as to the amount or timing of food consumption but must select their food from among the defined food choice array for the given stage.

AMPLITUDE (A): a measure of extent of rhythmic change--one of the three parameters used to define a rhythm (the other being "phase" and "period"). How far a rhythm deviates from the mean of the function (i.e., mesor or metrum) used to approximate the rhythm. The double amplitude (2A) is a measure of the total predictable change, and should be distinguished from the actual range of the raw data (difference between the highest and lowest recorded values) which may be much greater.

AUTORHYTHMOMETRY (AR): special case of rhythmometry with data collection by self-measurements (and/or automatic recording) of physiologic variable(s) as a function of time with ensuing fit of mathematical functions for inferential statistical rhythm and/or other temporal parameter description and point-and-interval estimation of characteristics such as mesor, amplitude, acrophase, period (or frequency) and/or waveform.

BATHYPHASE: a measure of a rhythm's timing, specifically the lag from a defined reference point, of the trough time of the cosine function used to approximate a rhythm, bathyphase is contrasted with the acrophase or crest time of the rhythm.

BIOLOGIC NOISE: random or other (useless) components (of a signal), interfering with the (useful) part of the signal (e.g., rhythm) to be evaluated.

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*Included in this glossary are terms commonly found in the literature of chronobiology; not all are used in this report but they do appear in the cited references. Certain of the terms included relate to military feeding or have been developed to aid discussion of the present experiment without redundant explanations.

BIORHYTHM: rhythm persisting as a fundamental property of biologic entities under various conditions of constancy in environmental factors (including those possibly known to synchronize the rhythm). Note: The term "biorhythm" has been misused in many contexts. It is here reserved for phenomena meeting testable criteria, several of them biologic in nature. *First, a biorhythm, as any rhythm, should constitute* a statistically significant entity-validated, for instance, by a test showing that its amplitude is not zero. Second, a biorhythm should persist for two or more cycles in an organism, organ, or other system isolated as far as possible from environmental cycles; e.g., in a cave or another medium with constant temperature, continuous light and unchanging availability to nutrients. Third, under such conditions, biorhythms usually exhibit a frequency that is statistically significantly (if slightly) different from that of an environmental cycle (the synchronizer) known (or assumed) to synchronize the biorhythm. Fourth, the institution of an abrupt (single cycle) shift by 90° or more *in the synchronizer should be followed by a "structured" adjustment* of the biorhythm's timing, the characterisitics such as rate, if not direction, of the rhythm shift depending on whether the synchronizer was advanced or delayed.

CHRONOBIOLOGIC SERIAL SECTION (SS): analytical results obtained by fitting a fixed-period cosine curve to consecutive overlapping or non-overlapping data sections, called intervals, displaced in increments throughout a time series-displayed with the original data and the probability values (of rhythm description), with point and interval estimates for mesor, amplitude and acrophase of the rhythm.

CHRONOBIOLOGIC WINDOW: tables showing results in terms of the adequacy of fit for cosines for various fixed periods of interest. In determining circadian (24-hour) rhythm, one might separately compute the wave for several exact periods, say from 20 hours to 28 hours, to determine which period gives the best fit.

CHRONOBIOLOGY: science objectively quantifying and investigating mechanisms of biologic time structure, including rhythmic manifestations of life.

CHRONOGRAM: a rectangular graph on which individual or average data is plotted as a function of time. The abcissa base shows time periods and subdivisions, usually with dates and clock times, while the ordinate is labelled according to the units of the measured variable; e.g., degrees C for oral temperature.

CIRCADIAN: relating to biologic variations or rhythms with a frequency of 1 cycle in 24 ± 4-hours; *circa* (about, approximately) and **dies** (day).

CIRCADIAN SYSTEM: a biologic entity exhibiting a (set of) variable(s) with a frequency of about one cycle per day; or a set of circadian rhythms characterizing a biologic entity.

CIRCANNUAL: relating to biological variations or rhythms with a frequency of 1 cycle in 1 year ±2 months.

COMPUTATIVE ACROPHASE (0): acrophase (q.v.) referenced to a physiologically arbitrary date and clock hour; e.g., midnight local time.

CONFIDENCE ARC: statistical confidence limits (e.g., 0.95) around the acrophase point, all usually expressed in degrees between 0° and 360°. It is shown graphically in a polar plot by the arc enclosed by the tangents to the error ellipse.

COSINOR: (abbreviation for cosine vector) statistical summary of the best fit of a cosine function to rhythmic data usually displayed on polar coordinates describing the amplitude and acrophase relations by the length and the angle of a directed line, respectively, shown with a statistical confidence region computed to (1) detect a rhythm (by a confidence-region not overlapping the pole), and (2) estimate confidence intervals for the rhythm parameters.

Note: Cosinor procuedures are of several kinds:

MEAN COSINOR (Cosinor–M): the original cosinor procedure applicable to three or more biologic series from an individual or a group for assessing the rhythm characteristics, if any, of an entire set. Inputs of cosinor–M are imputations consisting of amplitudes and acrophases from each indivdual series. Cosinor–M is applied when the mesors from individual series are different but the amplitudes are similar and the number of data points from each series is approximately equal.

SINGLE COSINOR (Cosinor–S): a cosinor procedure applicable to single biologic time series or to a set of series (from an individual or group) which all have similar mesors and similar amplitudes.

NUMBER–WEIGHTED MEAN COSINOR (PONDERATUS) (Cosinor–P): a cosinor procedure weighted with the number of observations in each series, applicable to two or more biologic series from one or more individuals when the mesors, amplitudes and particularly the number of data points in each series are quite different.

CYCLE: the whole of consecutive states and/or specifiable changes or events recurring in a physiologically integrated fashion with a recognizable frequency. Cycle with environmental qualification, e.g., light cycle, may be an appropriate term for environmental change showing recurrent pattern, whenever the role of this cycle as "synchronizer" is not clarified.

DESYNCHRONIZATION: state of two or more previously synchronized rhythmic variables that have ceased to exhibit the same frequency and/or the same acrophase relationships and show changing time relations. Note: As a result of desynchronization among the rhythms of separate individuals, a group rhythm may disappear; rhythm obliteration may falsely be inferred if individual rhythms are not separately monitored.

DIURNAL: relating to biologic variations or events occurring between sunrise and sunset or during illuminated fraction of a near-daily schedule of alternating artificial light and darkness.

DYSCHRONISM: time structure (including rhythm) alteration associated with demonstrable physical, physiological or mental deficit, if not disease; may be transient (e.g., individual traveling).

ENDOGENOUS (or INTERNAL) RHYTHM: refers to a rhythm which is synchronized by an organismic mechanism or pacemaker.

ENTRAINING AGENT: a forcing cycle, impelling another cycle to assume synchronization, i.e., its frequency, or an integer multiple or submultiple of its frequency. Synonym: SYNCHRONIZER, ZEITGEBER, ENTRAINING CYCLE.

ENTRAINMENT: interaction between two or more organismic rhythms or the effect upon rhythm(s) of an (external) synchronizer resulting in identical frequencies among interactants or in frequencies constituting integral multiples of one another (frequency-multiplication or demultiplication); can be due to either an internal or external entraining cycle.

ERROR ELLIPSE: measure of variability (i.e., 0.95 confidence region) of the amplitude and the acrophase of a rhythm as indicated by the size and form of the ellipse on a polar plot. Center point of the ellipse is the amplitude of the fitted cosine function, shown by the end point of the "clock hand". If the ellipse encompasses the polar center point, the cosine estimate is considered nonsignificant, i.e., periodicity cannot be claimed at the 0.95 confidence level.

EXOGENOUS (or EXTERNAL) RHYTHM: refers to a bodily rhythm which is synchronized by an environmental influence (or Zeitgeber) which is outside the organism.

EXTERNAL ACROPHASE (ρ, lower case phi): acrophase referred to a point on the synchronizing environmental cycle (SYNCHRONIZER). The external acrophase shows the rhythm's time relation to an environmental cycle known or presumed to act as (frequency) synchronizer--such as the midpoint of the daily light-span for nocturnally active animals kept in alternating light and darkness.

FOOD CHOICE ARRAY: the set of foods from which subjects chose what they would eat. Depending on the stage of the experiment, the array would include the entire set of LRP, MCI, or Frozen rations or a complete combined set of the latter two.

FREE–RUNNING: desynchronized in the sense of exhibiting a continually and systematically changing phase relation to the schedule of a habitual (known) synchronizer, following, e.g., removal of synchronizing stimuli or of their organismic transducer(s) or other major interference with the signal or its reception.

FREQUENCY (of a rhythm): the reciprocal of the period T, that is 1/T.

GPS (GENERAL FOOD PREFERENCE SURVEY or TEST): a standard food preference questionnaire for military populations developed at the US Army Natick Laboratories, (now called the U.S. Army Natick Research and Development Command) in 1971. The survey asks the individual to rate 378 foods on both a hedonic (like-dislike) scale and on a desired monthly frequency scale (see Appendix). Those foods on the GPS whose names closely correspond to the military ration items (i.e., MCI or Frozen) are termed GPS ration foods. Nonration foods are items which appear in the GPS but which are not included in any available choice array.

INFRADIAN: relating to certain biologic variations or rhythms with a frequency lower-than-circadian, specifically rhythms with a frequency less than one cycle in 28 hours.

INTERNAL ACROPHASE (Φ, capital phi): acrophase referred to the acrophase of another rhythm with the same frequency in the same organism. The acrophase of body temperature or of urinary potassium or corticoid excretion may serve as a (preferred) reference time marker, but if these are not available, the midpoint of the habitual sleep-span may be substituted.

LRP (LONG RANGE PATROL) RATION or FOOD PACKET: a special military operational subsistence flexible packet containing a precooked freeze-dehydrated main dish in a reconstitution packet. It can be eaten dry, but preferably should be rehydrated using hot water. A total of 8 different packets are available.

MCI (MEAL, COMBAT INDIVIDUAL): a general military operational ration in canned form which in the early 1960's replaced the C Ration used in World War II, and which is packed for individual use.

MEAN (sample, $\bar{Y}$): average of sample which may or may not coincide with the mesor.

MESOR (M): rhythm-determined average; e.g., in the case of a single cosine approximation, the value midway between the highest and lowest values of function used to approximate a rhythm.

PACEMAKER: organismic entity controlling or influencing rhythmic activity. Note: Most commonly, the term "pacemaker" refers to the heart's rhythmic centers. The meaning of the term has been broadened to include any internal mechanisms generating rhythms.

PERCENTAGE RHYTHM (PR): percentage of variance of measured phenomenon accounted for by a fitted model; may be referred to as "circadian quotient" when the rhythm is daily.

PERIOD (T tau): the absolute amount of time covered by one complete cycle of a rhythm, i.e., the elapsed time between two peaks or two troughs of a wave. One cycle may usually be adequately estimated from six points of observation if equally spaced throughout the period.

PERIODICITY: regularly repetitive changes occurring in animate or inanimate nature, irrespective of waveform or of underlying mechanisms.

PHASE (Θ, theta): a location on the wave or cycle, either a point (e.g., acrophase) or a span (e.g., light or dark), that is a stage in the wave.

PHASESHIFT: single abrupt or gradual displacement of a periodicity along the time scale.

PHOTOPERIOD: the duration and time of occurrence of the light span of one complete light-dark cycle of the environment.

PLEXOGRAM: display of original data covering or collapsing over spans longer than the period of the investigated rhythm and plotted along an abscissa of a single period, irrespective of the time order of collection (e.g., as a function of a day irrespective of calendar date).

POLAR COORDINATES: a point on a polar plot defined as the end point of a radius vector ("clock hand"), identified by its direction (0° to 360°) and distance from the center point.

POLAR PLOT (or COSINOR CLOCK): a 360° compass rose on which rhythms may be plotted. The circle perimeter may also be marked in units of time. When a 24 hour (i.e., circadian) rhythm is plotted, 0° to 360° equals 24 hours and each hour is represented by 15° of angle. Polar plots in chronobiology conventionally place 0°, 360° (0, 24 hours) at the top of the circle for clockwise reading where 0, 24 hours equals to 0° to 360°. This orientation requires that the degrees be shown as minus figures because long established mathematical convention differs from chronobiologic convention by reading the degrees counterclockwise with zero located on the right-hand side. In effect, the conventional mathematical plot is rotated and viewed from the opposite side, i.e., flipped over.

RADIUS VECTOR: the "clock hand" of a cosinor polar plot, by its direction indicating time within the cycle, or degrees 0° to 360°, and by its length indicating the magnitude (amplitude) of the phenomenon which is shown at the time of its highest point (acrophase).

RATION FOOD: any food included in the choice array available to the subjects during any of the experimental stages. Because of the nature of the experimental design, ration foods are restricted to the food items included in the military MCI, LRP, or Frozen rations.

RHYTHM: a periodic component of (biologic) time series, with objectively quantified characteristics; i.e., a frequency, acrophase, amplitude, mesor, and/or waveform demonstrated by inferential statistical means.

RHYTHMOMETRY: detection of rhythm by inferential statistics and point-and-interval estimation of characteristics such as mesor, amplitude, acrophase, period (or frequency), and/or waveform.

SPS (SPECIFIC PREFERENCE SURVEY OR TEST): questionnaire survey of preference for ration food items. There are three versions: LRP ration SPS, MCI ration SPS, and Frozen ration SPS (see Appendix B).

SYNCHRONIZATION: state of system when two or more variables exhibit periodicity with the same frequency and acrophase or with frequencies that are integer multiples or submultiples of one another.

SYNCHRONIZER (OR ZEITGEBER): environmental periodicity determining the temporal placement of a given biologic rhythm along an appropriate time scale, by impelling the rhythm to assume synchronization, i.e., its frequency or an integer multiple or submultiple of its frequency.

TRANSVERSE STUDY: a study that combines data into a single harmonic analysis which includes groups of subjects and varying numbers of observations at different or unequally spaced intervals.

UBIQUITOUS RHYTHM: an average rhythm that describes closely the individual rhythms of many individual people.

ULTRADIAN: relating to biologic variations or rhythms with a period less than circadian. Specifically, rhythms with frequencies greater than one cycle in 20 hours.

VARIATION. COEFFICIENT OF: standard deviation of a distribution divided by the arithmetic mean (sometimes multiplied by 100). Served to compare variabilities of samples or populations and is independent of units and magnitudes of means, but is sensitive to errors in the means.